HYDROLOGIC CHARACTERISTICS OF LAND CLASSES AT COAL CREEK, OKLAHOMA EMRIA STUDY AREA

by

Gregg C. Lusby

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The Coal Creek study area was divided into four major land classes, each of which possess runoff characteristics which are similar over its areal extent. Rainfall-simulation runs were made on three of the land classes to determine the hydrologic characteristics of the class as baseline data for comparison with future changes which might occur from surface mining. The extent of each land class was determined from areal photographs and soils maps provided by the Soil Conservation Service and is shown on the accompanying map (see plate 1, in pocket). A response similar to that obtained from the applied simulated rainfall could be expected from areas of the same hydrologic class shown on the map. The simulation sites were chosen to be representative of the terrain within each hydrologic class. However, runoff and sediment-yield values may have to be altered somewhat to compensate for radically dissimilar slopes and soil depth.

Methods used to obtain the data from each simulation site listed in table 1 are as follows:

1. Runoff—Measured in a Parshall flume with 1-inch throat. Readings of stage were made at 1-minute intervals and converted to discharge in cubic feet per second. From these data, a runoff hydrograph was constructed and total volume of runoff was computed and expressed in inches per unit area. From these data, an infiltration curve was also constructed by subtracting the runoff from the rainfall applied for each 1-minute increment and expressing as the infiltration rate in inches per hour.

2. Precipitation—Measured in a network of rain gages within the study area. Rainfall for the total area was computed using the Thiessen Polygon method. Rainfall is normally applied for a duration of about 45 minutes. Because of high infiltration rates encountered at Coal Creek, adjustments were made to apply more water on some of the areas in about the same time.

3. Sediment yield—Water samples were obtained from the outflow at 3-minute intervals and were analyzed for sediment concentration. The sediment concentrations were plotted and a concentration curve was drawn between points. From this curve, a concentration was obtained for each minute and was used in conjunction with the discharge for that minute to compute the sediment load. Total sediment load is expressed in pounds and in tons per square mile.

Table 1.--*Data obtained from simulation sites at Coal Creek, Oklahoma*

Variable. . .	1-1	1-2	2-1	2-2	3-1	3-2	4-1	4-2	5-1	5-2
Date.	9-15-78	9-16-78	9-17-78	9-19-78	9-20-78	9-22-78	9-23-78	9-24-78	9-25-78	9-26-78
Area (square feet)	2,373	2,373	2,243	2,243	1,831	1,831	1,121	1,121	996	996
Weighted mean slope (percent)	4.8	4.8	3.3	3.3	7.9	7.9	6.6	6.6	7.1	7.1
Antecedent moisture (percent)	8.8	22.0	7.8	13.4	8.9	14.0	13.8	16.8	6.9	14.8
Clay (percent)	20	20	14	14	7	7	12	12	6	6
Root concentration ($g/decimeter^3$)	13.2	13.2	15.3	15.3	14.6	14.6	9.5	9.5	8.8	8.8
Bare soil and rock (percent)	1.0	1.0	0	0	11	11	3	3	7	7
Precipitation (inches)	1.64	1.66	1.69	2.34	3.14	3.17	3.13	2.72	1.77	1.81
Runoff (inches)	0	.12	0	.03	1.19	1.43	.19	.91	.29	.54
Sediment yield (pounds)	0	.13	0	.03	.88	.66	.15	.25	.24	.37
(tons per square mile)	0	.76	0	.19	6.70	5.02	1.87	3.11	3.36	5.18

4. Area—Obtained from a topographic survey of the site. Expressed in square feet.

5. Weighted mean slope—Obtained by measuring the area between contours and weighting the slope of that area according to the percentage the area is of the whole.

6. Antecedent moisture—Obtained from gravimetric samples of the top 10 centimeters of soil. Samples are usually taken at four locations within the site and are averaged for the final result. Expressed as percentage by weight. Two runs are normally made at each site. The first in a dry condition and again after the water in the soil has come to gravimetric equilibrium. Soil moisture samples are taken before each run.

7. Clay—Obtained from soil samples taken from the top 10 centimeters of soil at numerous locations within the site. Samples are analyzed for percentage by weight of material less than 0.002 millimeters in diameter.

8. Root concentration—The amount of fibrous root material in the top 10 centimeters of soil. Expressed in grams per cubic decimeter of soil.

9. Bare soil and rock—Obtained from three 20-foot transects within each site using a point frame and the first point-contact method. Pins lowered to the vegetation or ground surface are recorded as first encountering aerial vegetation, mulch, bare soil, or rock. Expressed as hits per 100 pins.

Precipitation

Precipitation events of various recurrence interval, duration, and magnitude were obtained from Weather Bureau T. P. 40 for the Coal Creek area. Estimated runoff for these events were computed using infiltration rates obtained from the simulation runs. These data are shown in table 2.

The infiltration rate of the soil during the early part of simulation runs usually exceeds the application rate of rainfall. In order to determine runoff values from natural rainstorms exceeding this rate, it was necessary to estimate the early part of the infiltration curve. This was done by extending the infiltration curve backward in time from the point of initial runoff using a power function based on plots of several defined curves and the theory that initial infiltration rate is infinite. The result of one of these computations is shown in figure 1.

Table 2.—*Estimated runoff, in inches, from storms of designated frequency, duration, and magnitude*

(Precipitation values from Weather Bureau T. P. 40)

Recurrence interval (years)	Magnitude (inches)	Simulation site							
		1-wet	2-wet	3-dry	3-wet	4-dry	4-wet	5-dry	5-wet
		30-minute duration							
1	1.2	0.06	0	0	0.13	0	0.07	0.14	0.28
2	1.5	.25	0	.13	.35	0	.25	.38	.53
5	1.9	.60	0	.48	.69	0	.55	.74	.91
10	2.3	1.00	.56	.86	1.08	.24	.91	1.14	1.31
25	2.6	1.32	.84	1.16	1.38	.50	1.20	1.44	1.62
50	3.0	1.76	1.22	1.57	1.79	.88	1.60	1.85	2.04
		60-minute duration							
1	1.6	0	0	0	0	0	0	0	.16
2	1.9	.03	0	0	.03	0	.03	.07	.39
5	2.5	.42	0	0	.49	0	.42	.54	.89
10	2.9	.74	0	.22	.83	0	.73	.89	1.25
25	3.3	1.13	.18	.61	1.22	0	1.11	1.30	1.63
50	3.7	1.49	.50	.96	1.57	.01	1.42	1.66	2.03

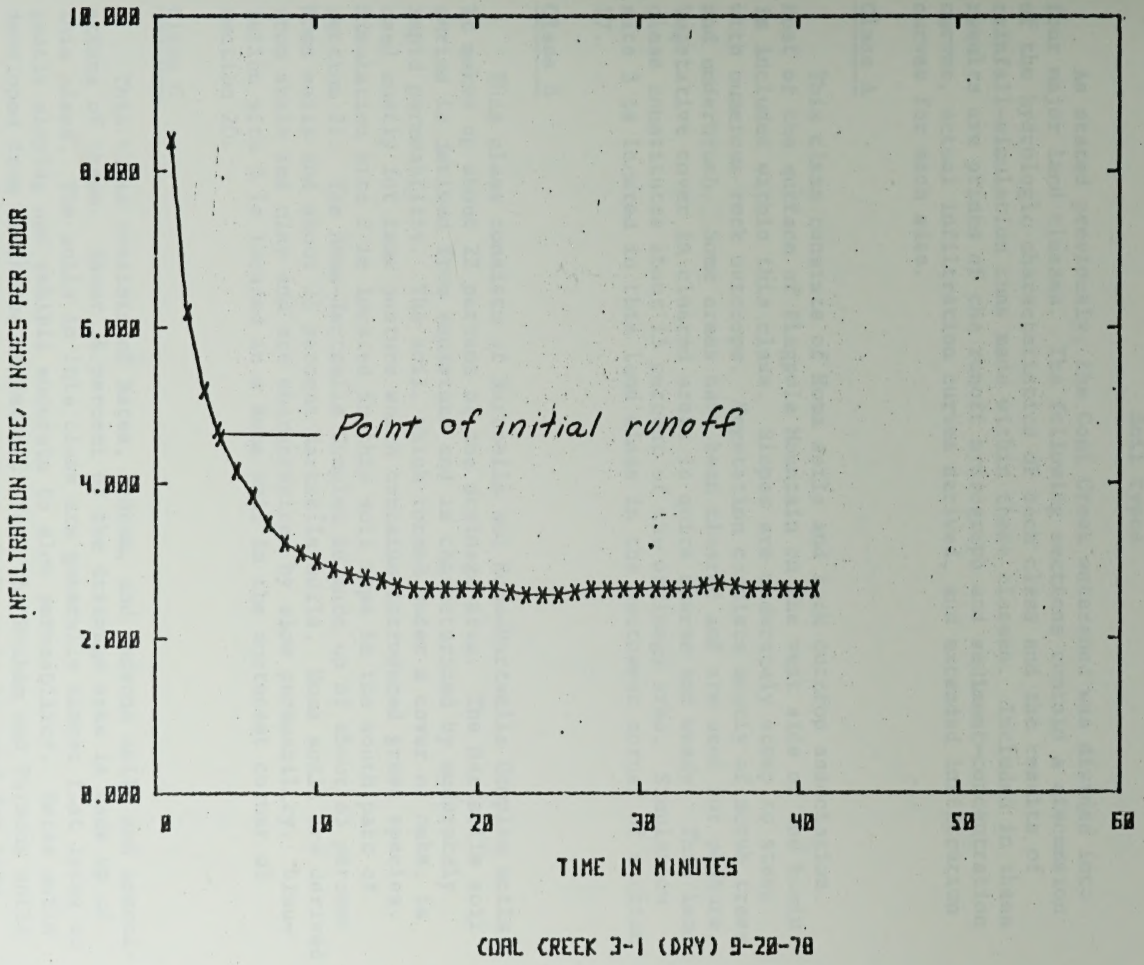
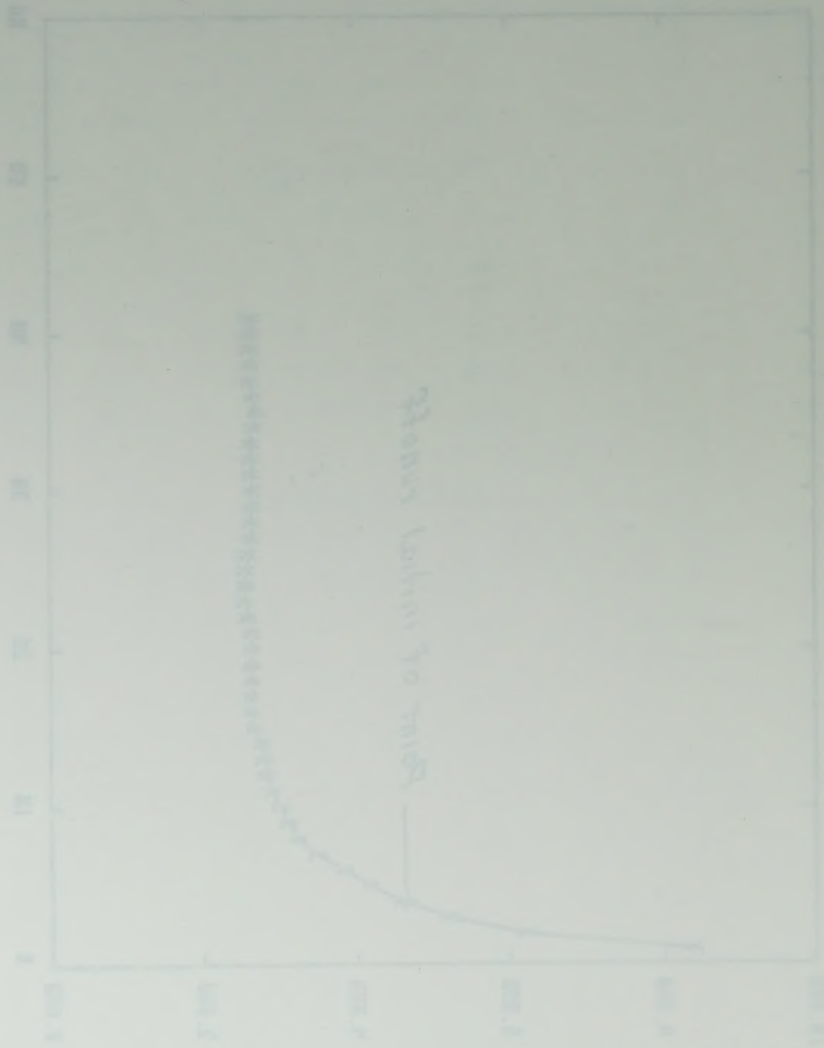


Figure 1.--Infiltration curve extended backwards from point of initial runoff.



No runoff occurred during the dry run at sites 1 and 2 and therefore the infiltration curves could not be defined. Inspection of the infiltration curves reveals that the curves for the wet run at sites 1 and 3 are quite similar. It is probable that the curve for the dry run at site 1 is similar to the curve for the dry run at site 3.

Soil types

As stated previously, the Coal Creek watershed was divided into four major land classes. The following sections contain a discussion of the hydrologic characteristics of each class and the results of rainfall-simulation runs made within these classes. Included in these results are prints of the runoff hydrograph and sediment-concentration curves, actual infiltration curves derived, and extended infiltration curves for each site.

Class A

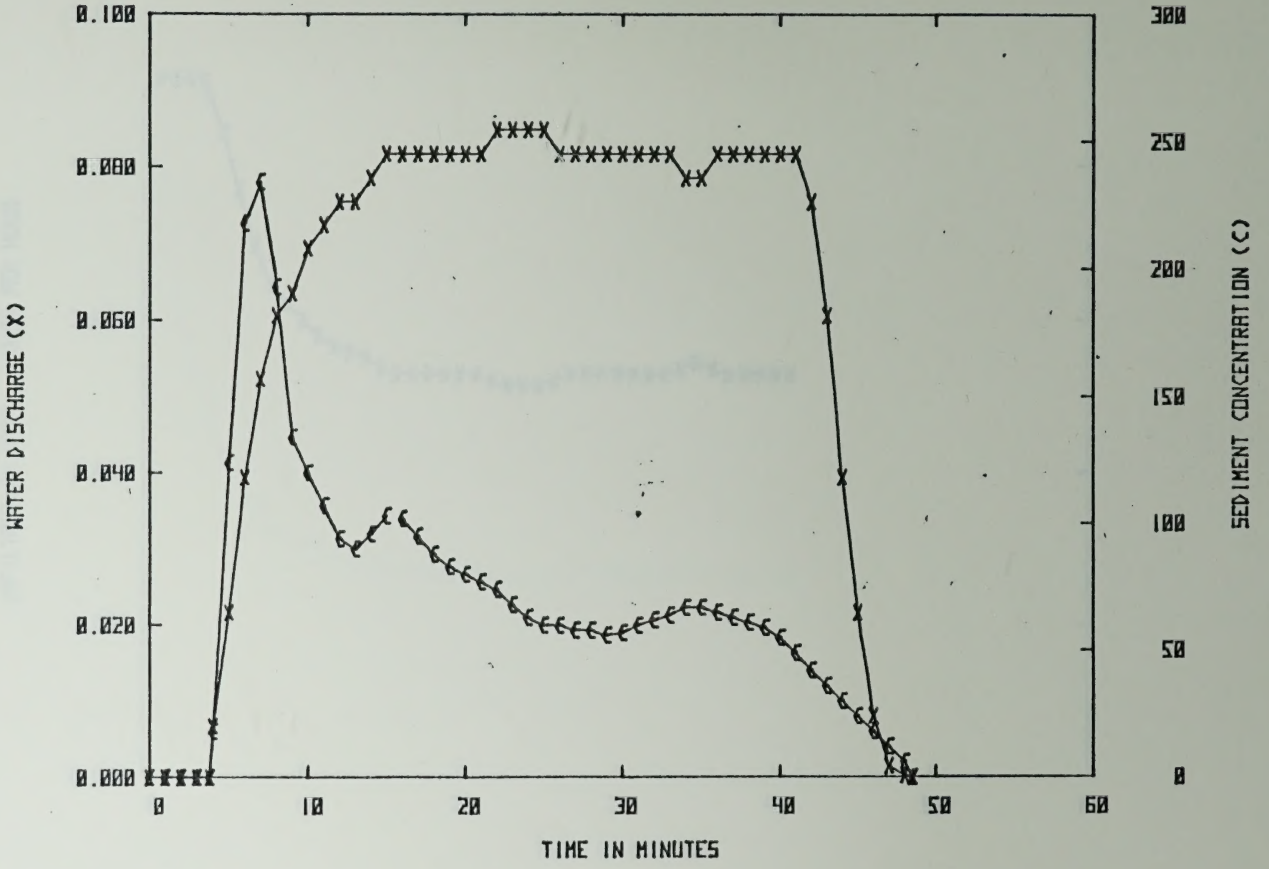
This class consists of Homa soils and rock outcrop association. Most of the surface of Flagpole Mountain on the west side of the basin is included within this class. Slopes are moderately steep to steep with numerous rock outcrops. Vegetation consists mostly of scrub trees and underbrush. Some areas have been cleared and are used for pasture. Vegetative cover in cleared areas is quite sparse and weedy. This land class constitutes about 15 percent of the drainage area. Simulation site 3 is located in this land class in the southwest corner of section 17.

Class B

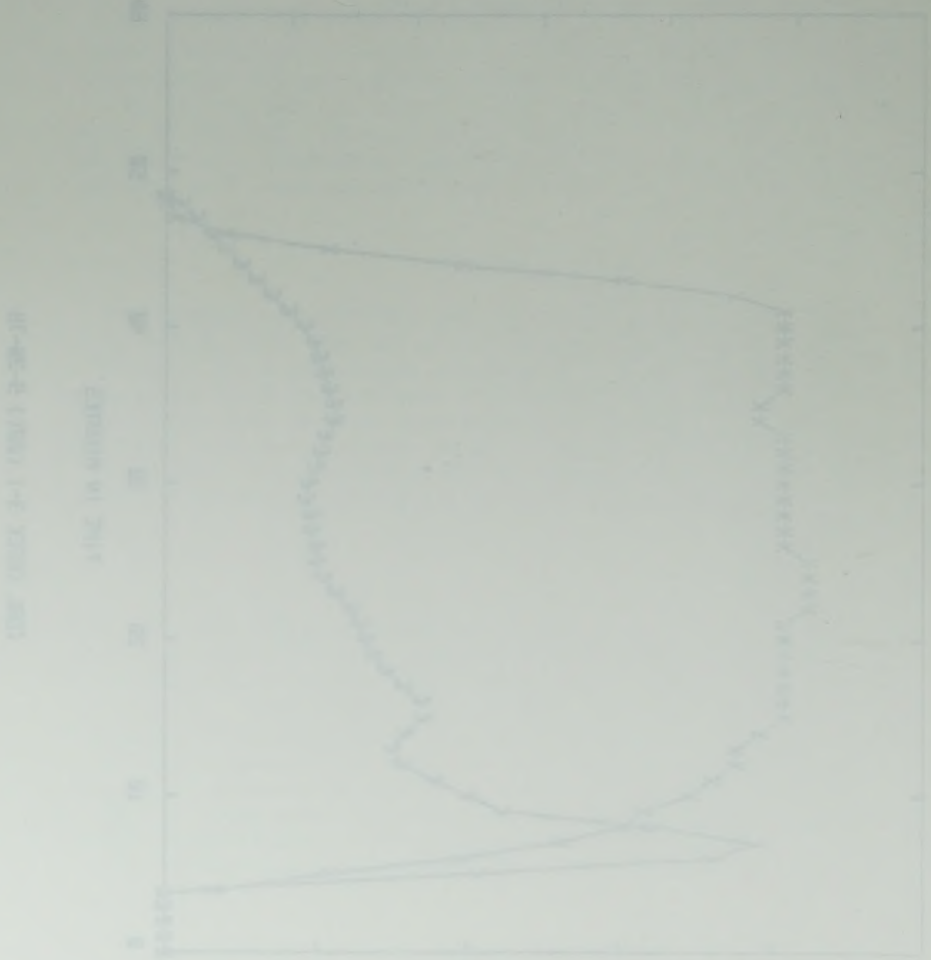
This class consists of Hartsells and Homa-Hartsells Complex soils. It makes up about 22 percent of the drainage area. The Hartsells soil series is derived from sandstone and is characterized by moderately rapid permeability. The soil, which formed under a cover of oaks, is used mostly for tame pasture which contains introduced grass species. Simulation site 2 is located in this soil type in the south part of section 21. The Homa-Hartsells Complex is made up of about 65 percent Homa soils and about 25 percent Hartsells soils. Homa soils are derived from shale and clay and are characterized by slow permeability. Simulation site 5 is located in a Homa soil in the northeast corner of section 20.

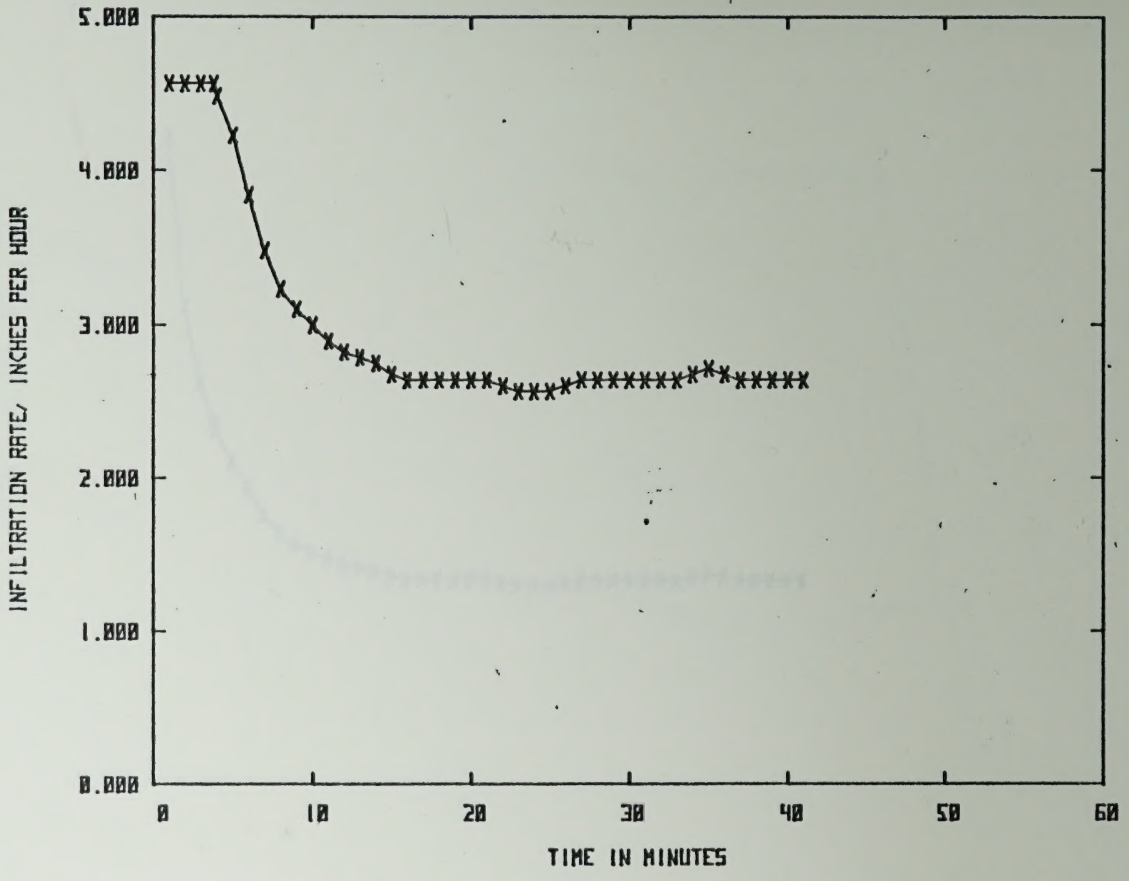
Class C

This class consists of Bates, Bonham, and Parsons soils and associations of these. About 36 percent of the drainage area is made up of this class. The soils in this class are generally almost flat lying to gently sloping and exhibit moderate to slow permeability. Bates soils developed from weathered sandstone. Both the Bonham and Parsons soils were derived from clay material. Most of the area is used for tame pasture or cropland. Simulation site 1 is located on a Bonham loam in the south part of section 22. Simulation site 4 is located on a Bates loam in the east side of section 20.



COAL CREEK 3-1 (DRY) 9-20-78





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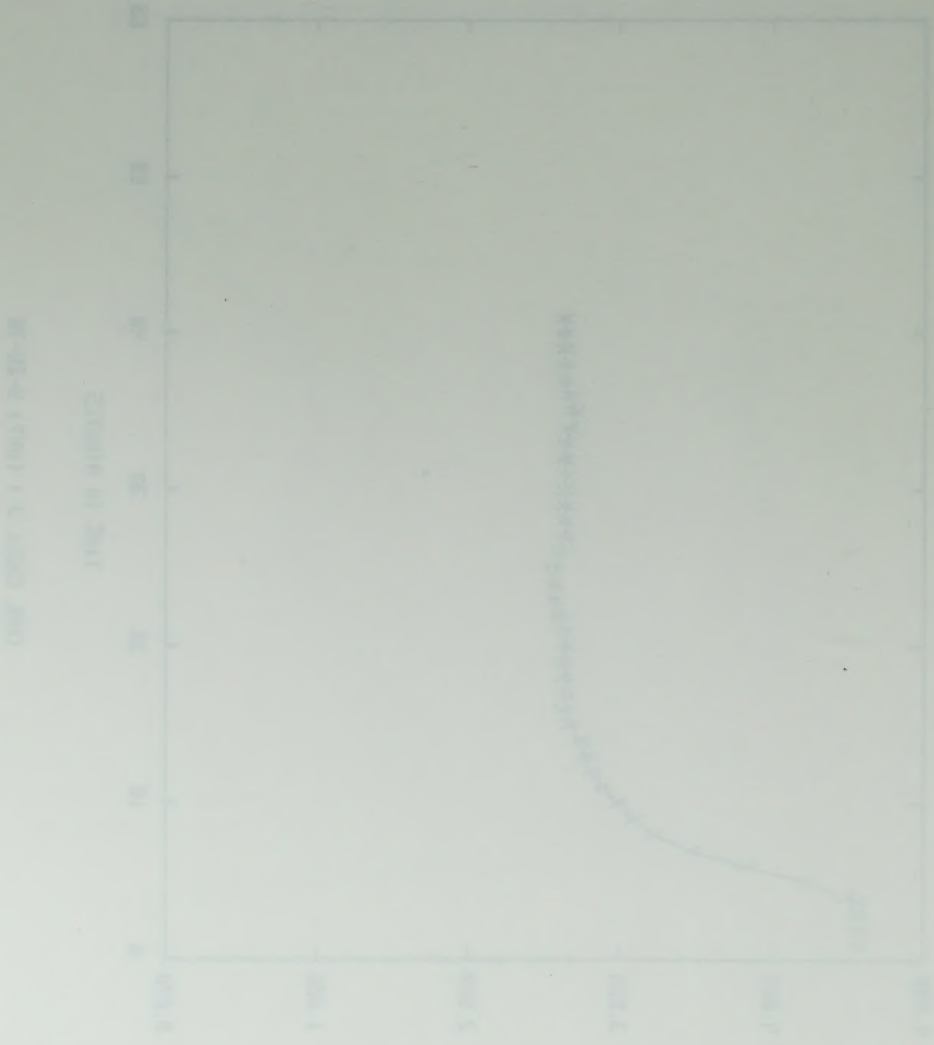

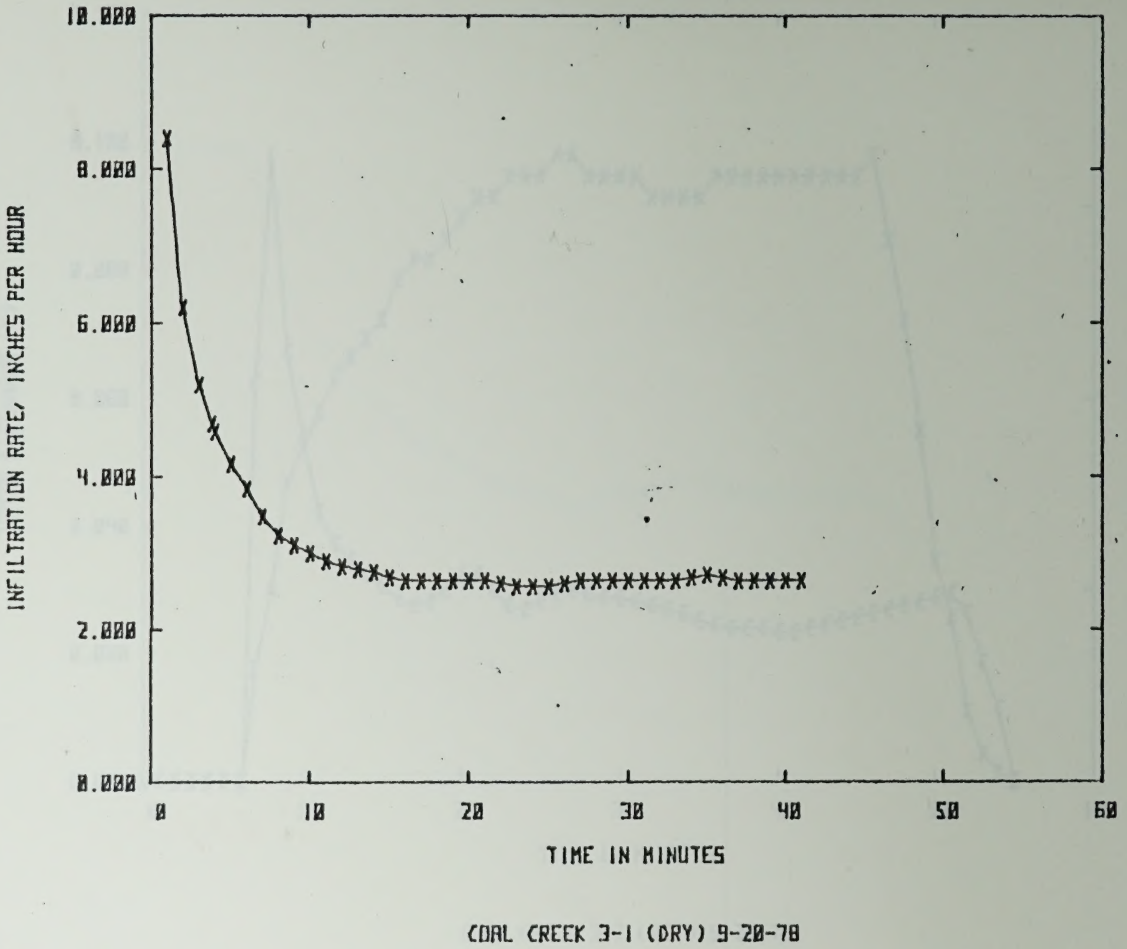

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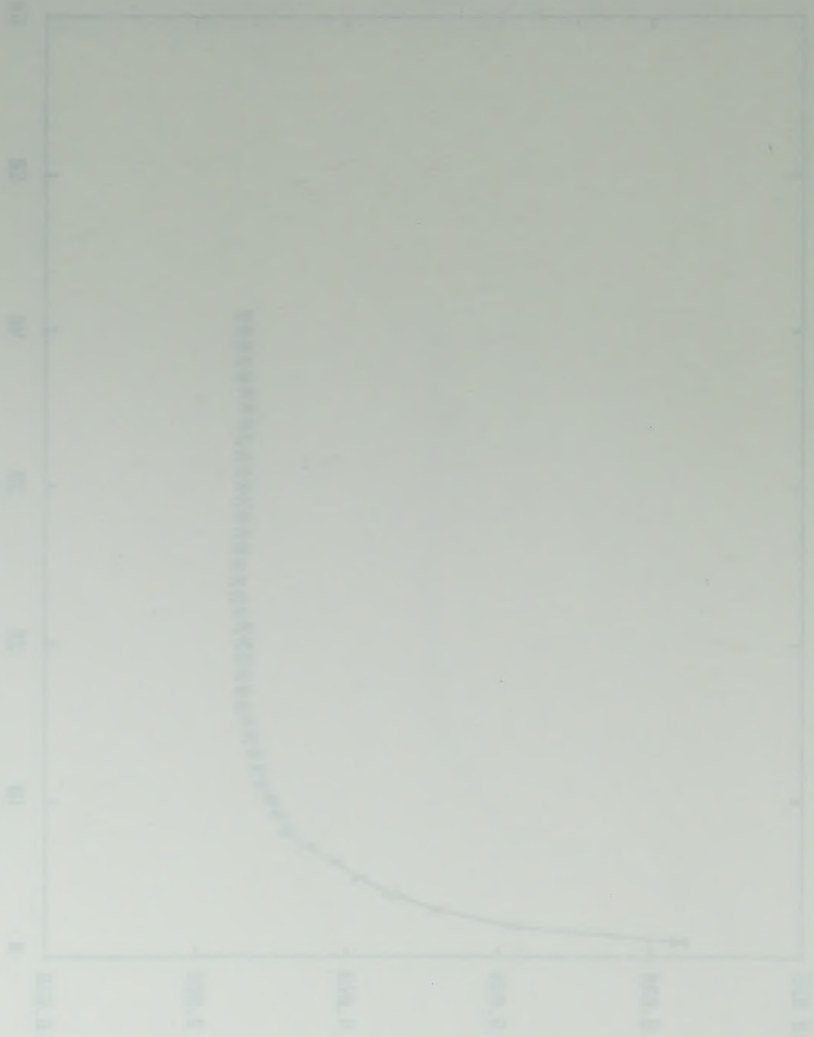

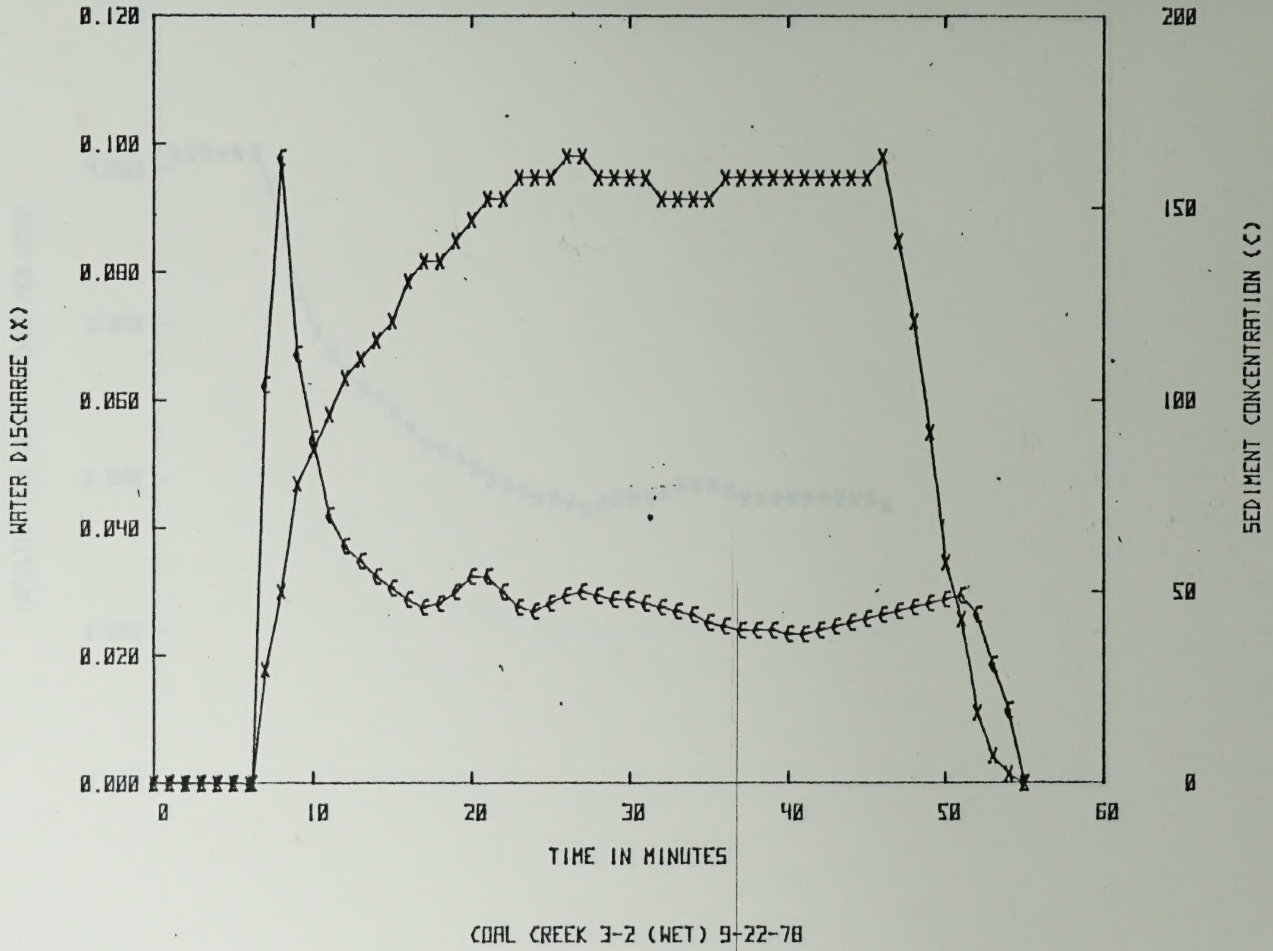
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WATER DISCHARGE (X)
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SEDIMENT CONCENTRATION (C)
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TIME IN MINUTES
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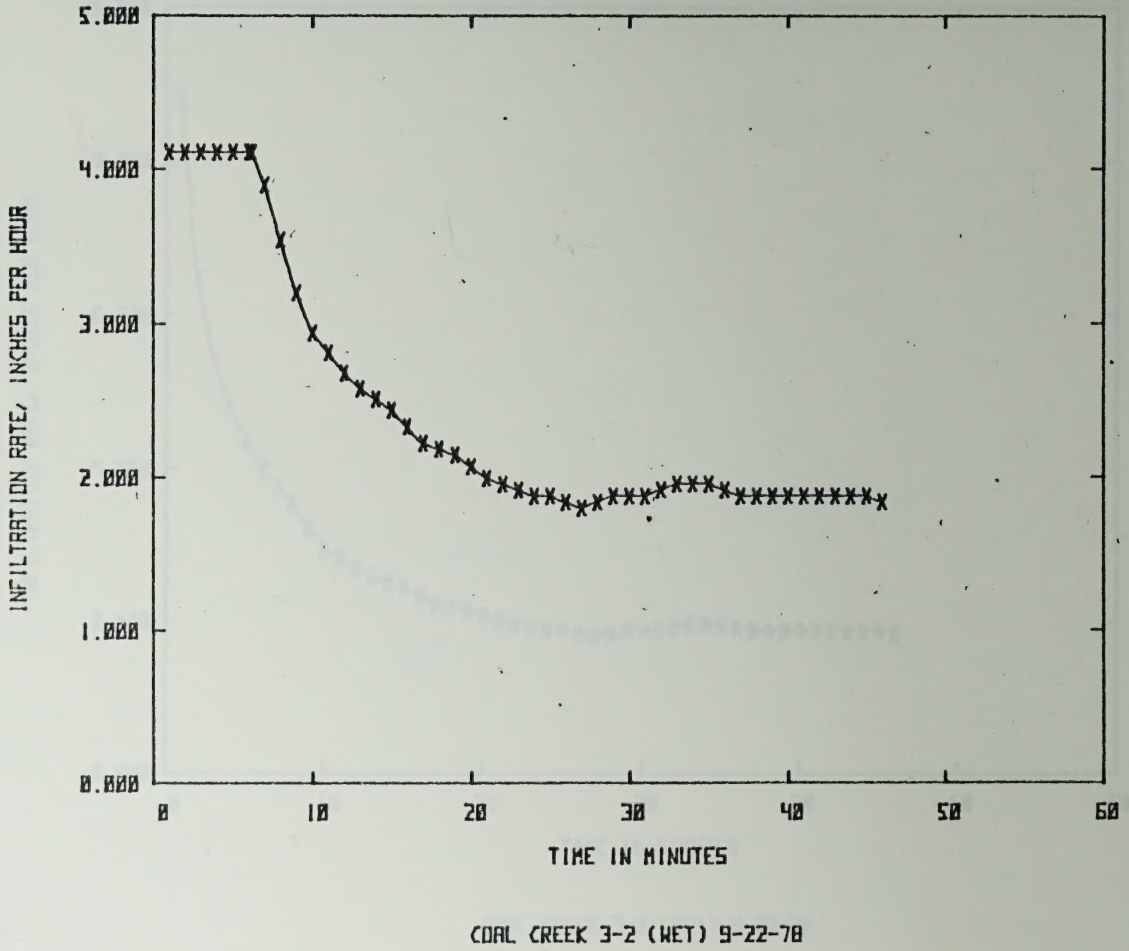

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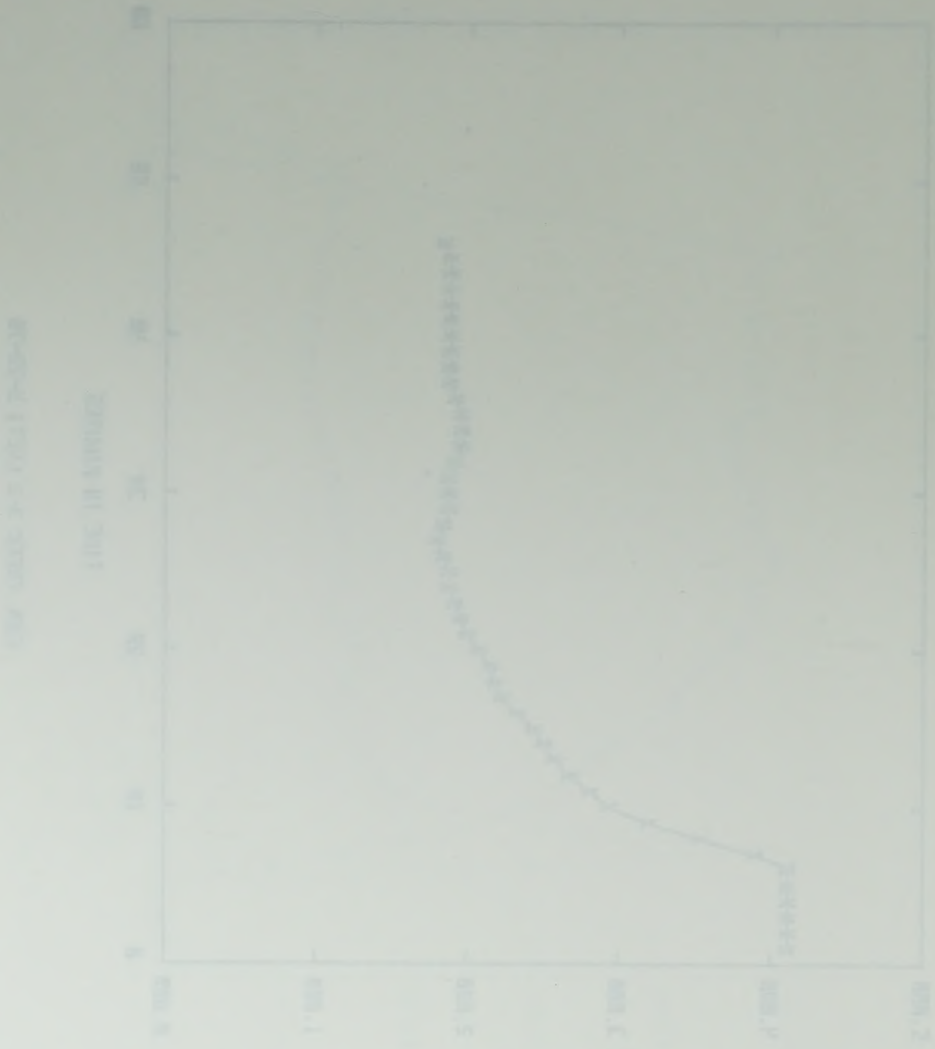

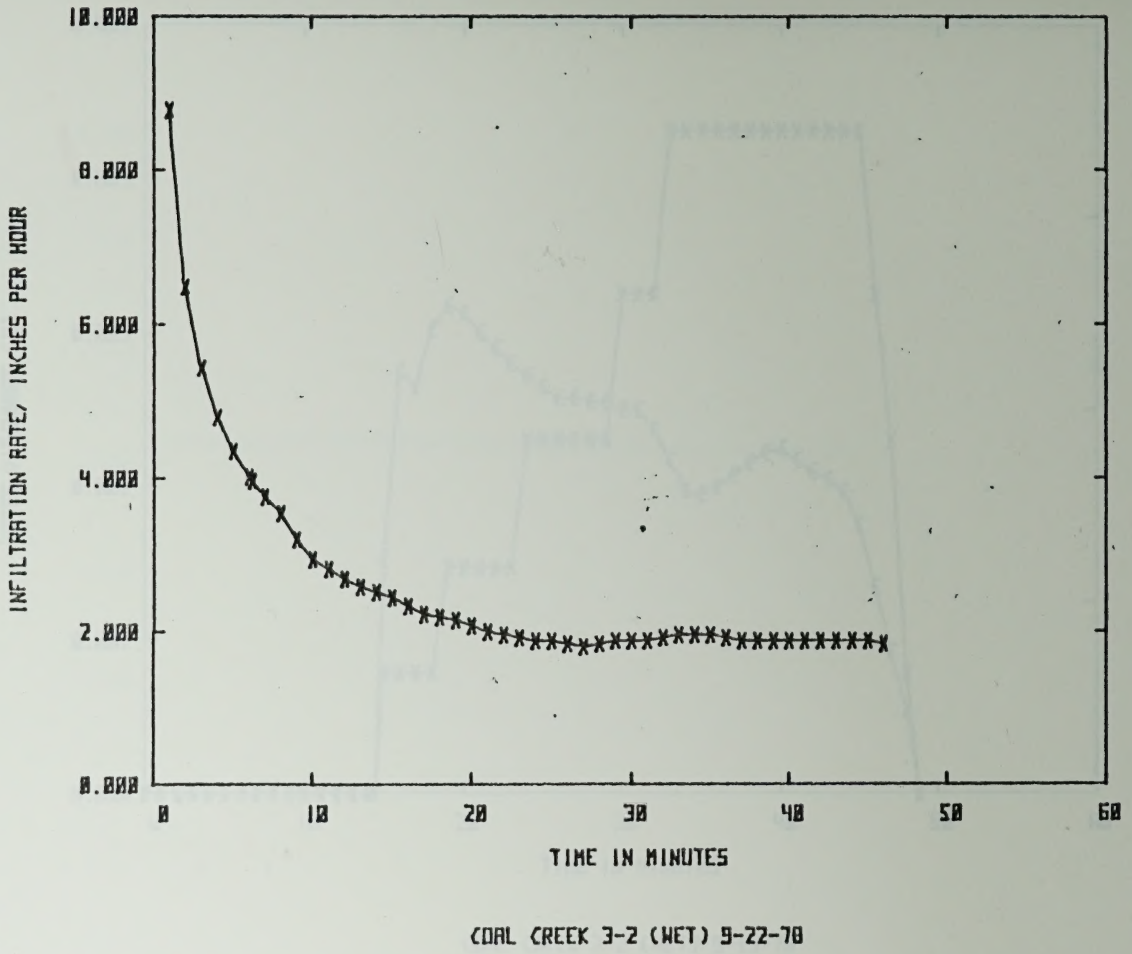
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INFILTRATION RATE, INCHES PER HOUR
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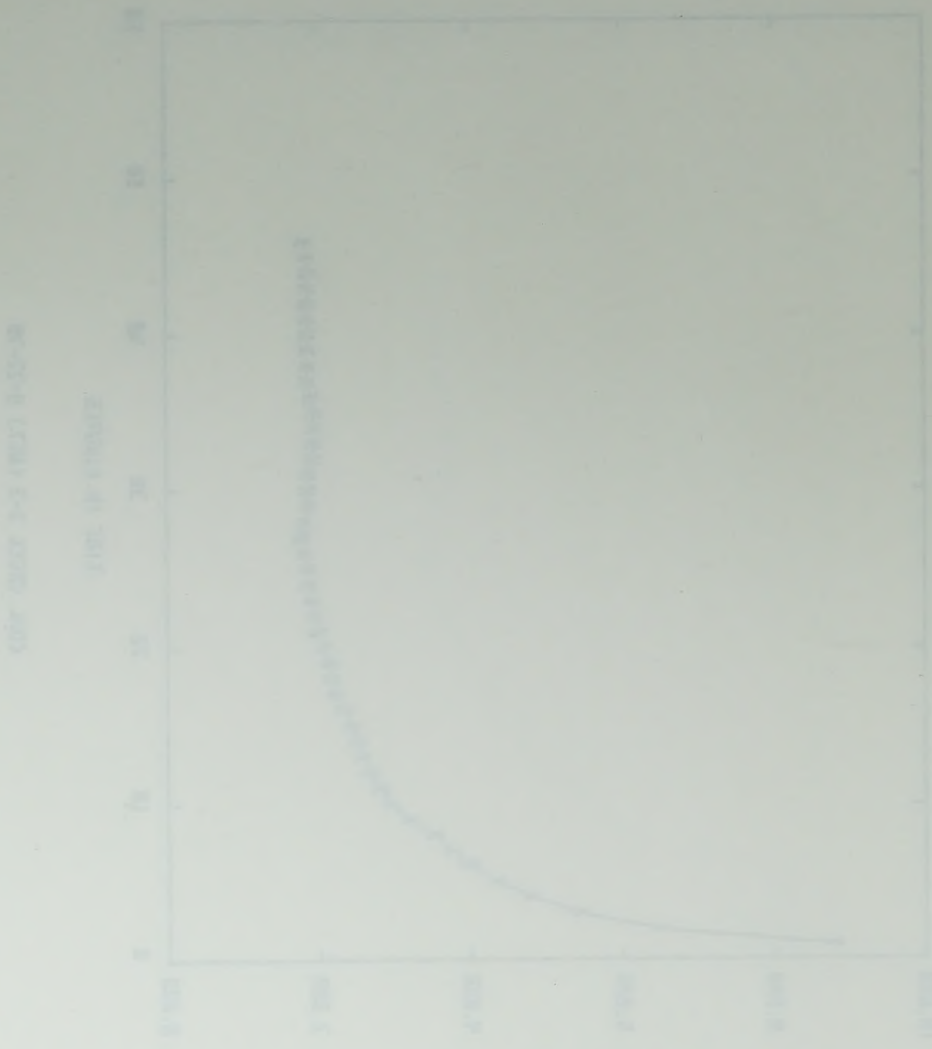
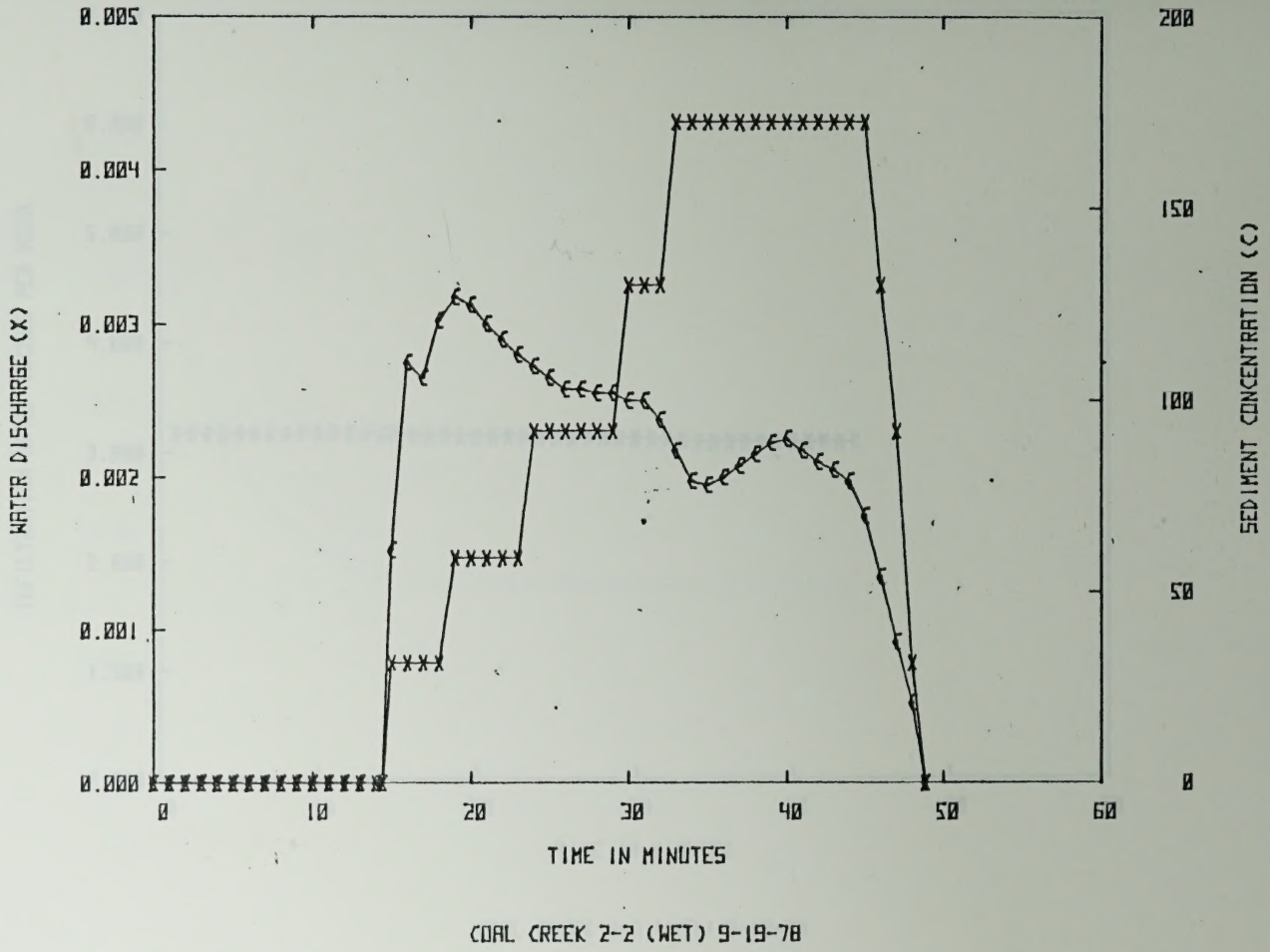
TIME IN MINUTES
COAL CREEK 3-2 (WET) 9-22-78





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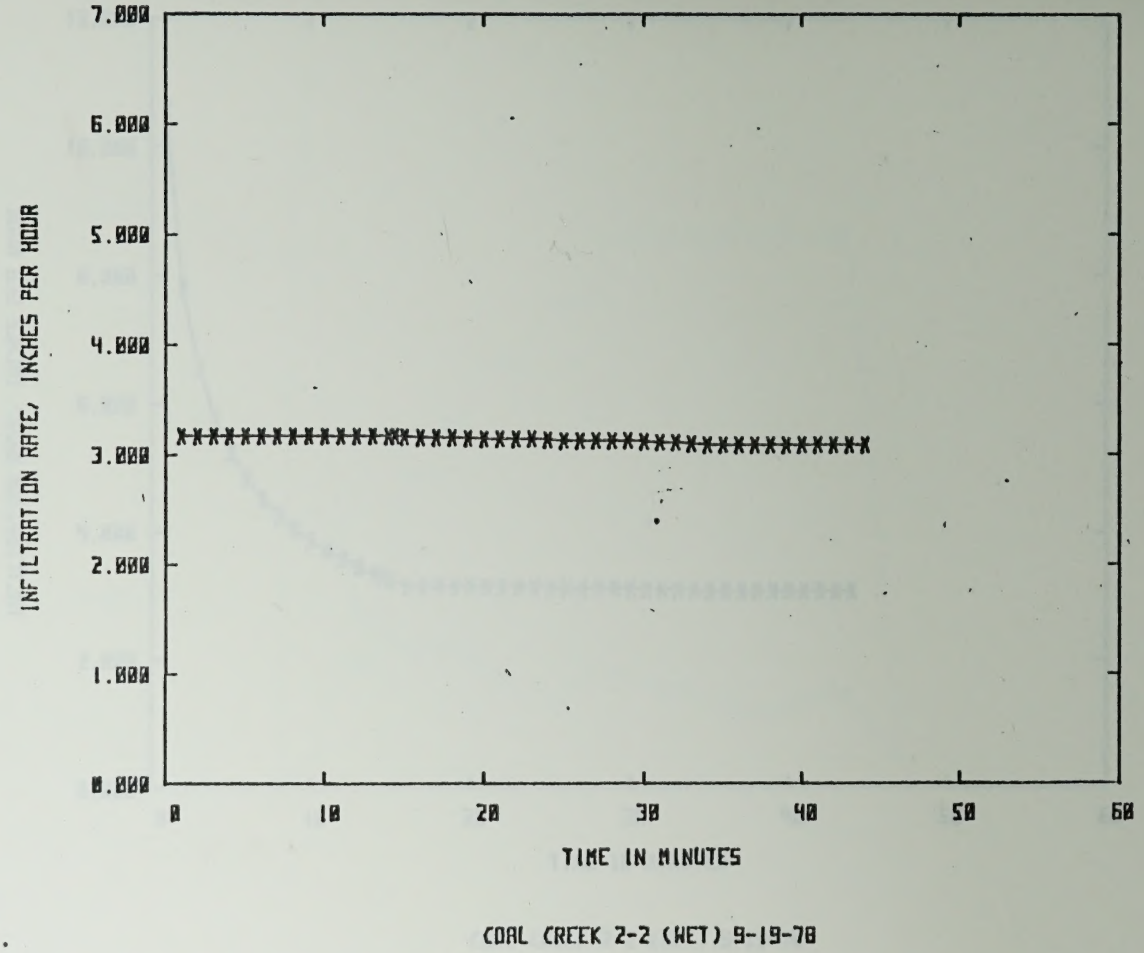
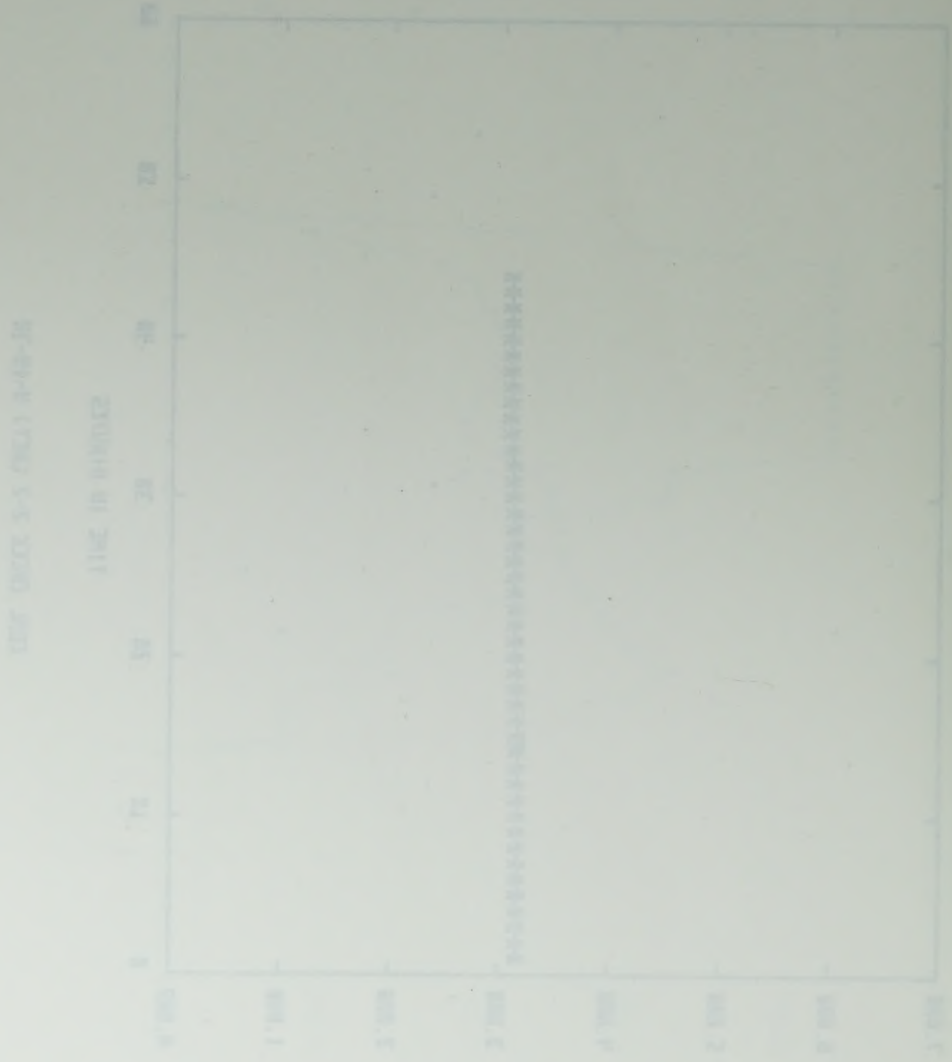
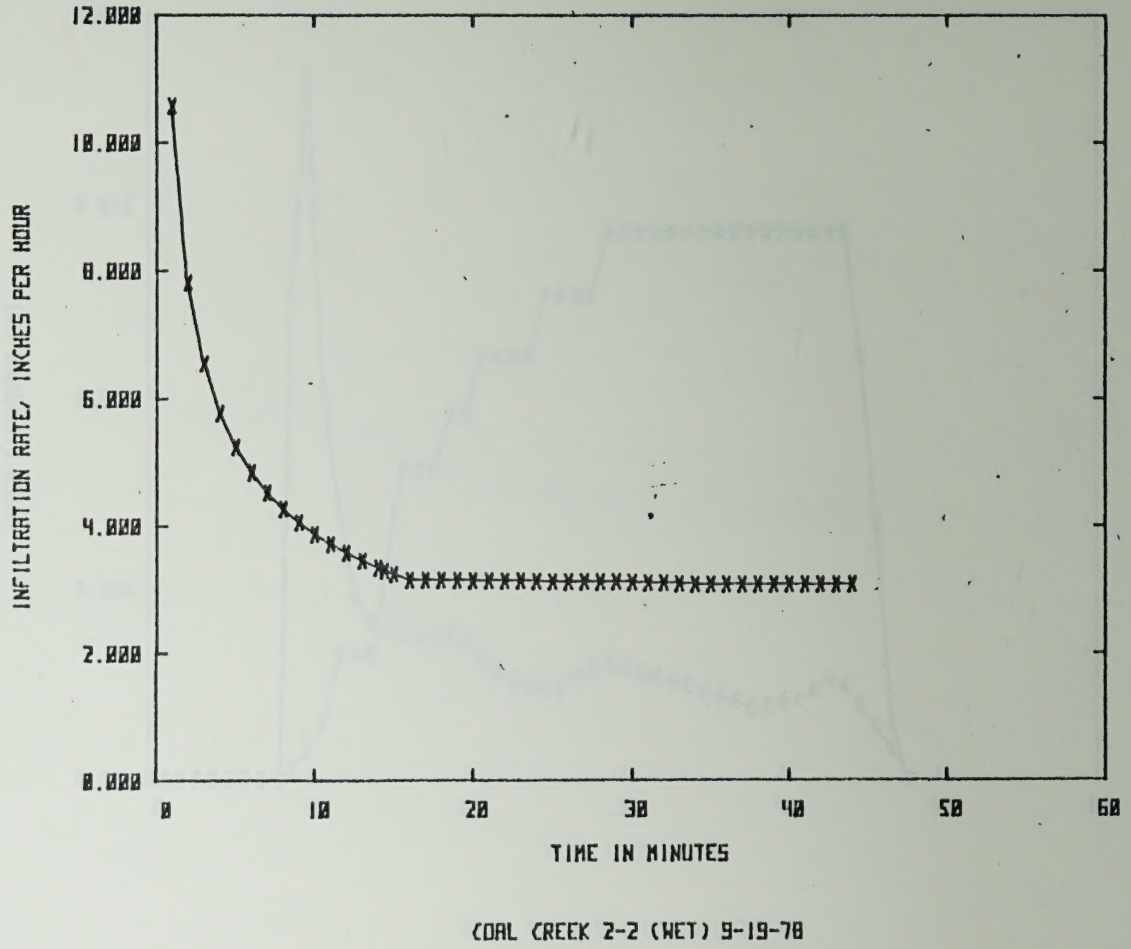


COAL CREEK 2-2 (WET) 9-19-78

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INFILTRATION RATE, INCHES PER HOUR
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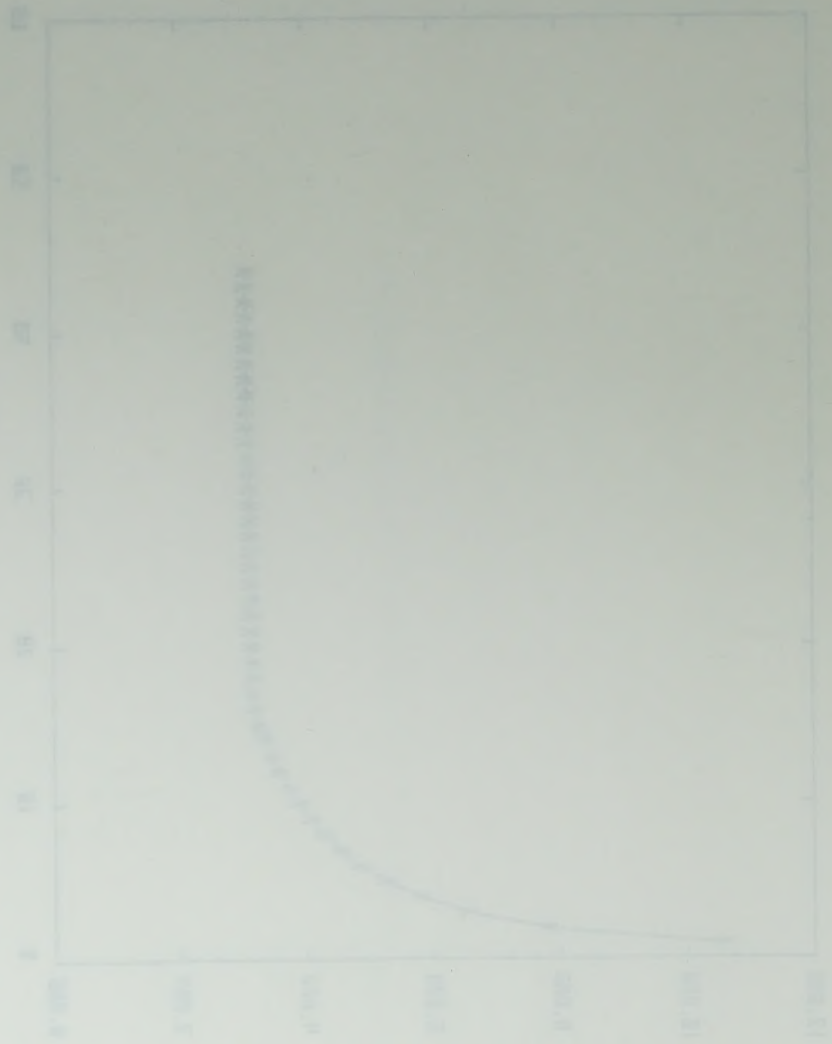
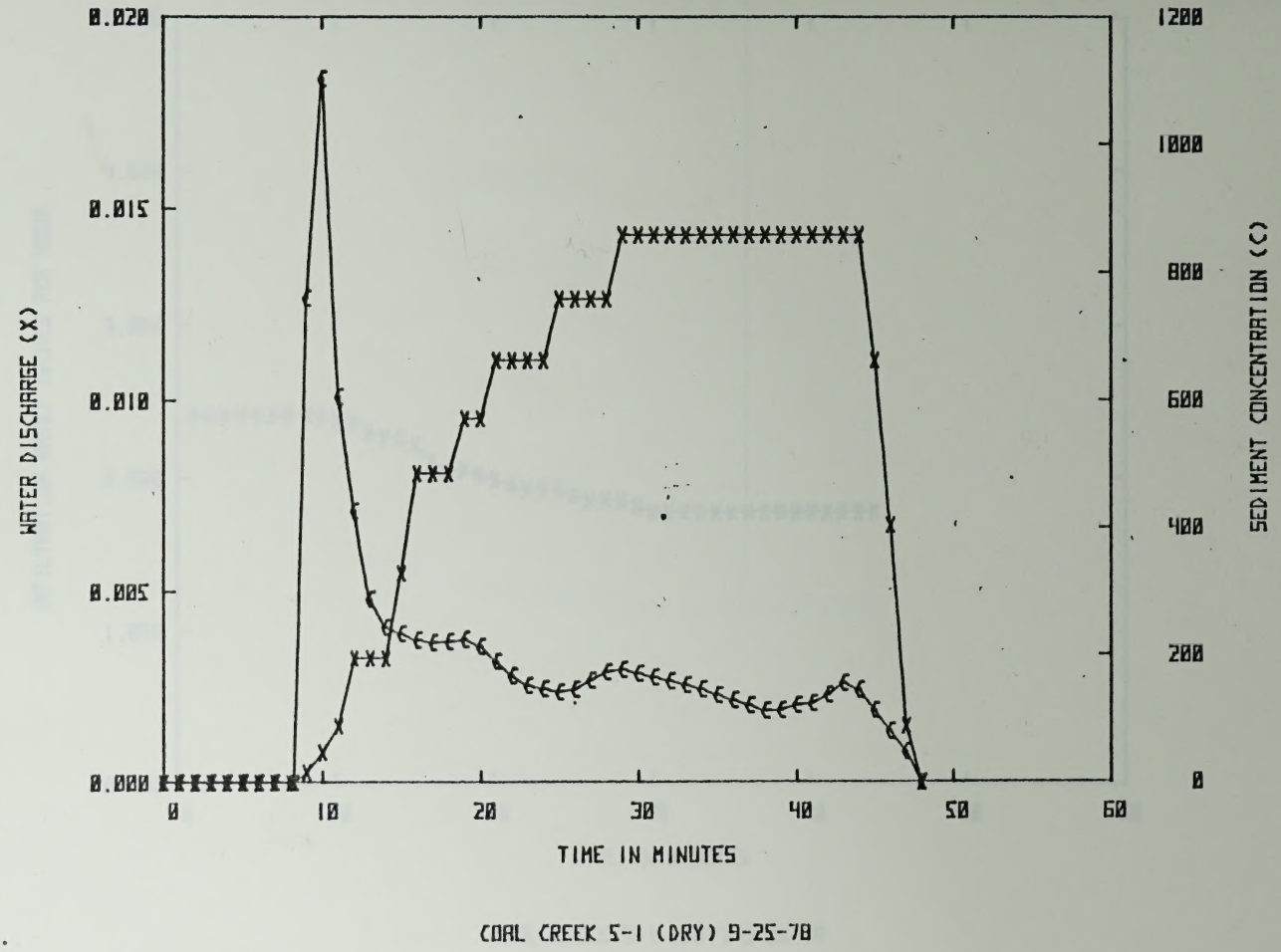
TIME IN MINUTES
COAL CREEK 2-2 (WET) 9-19-78

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SEDIMENT CONCENTRATION (C)
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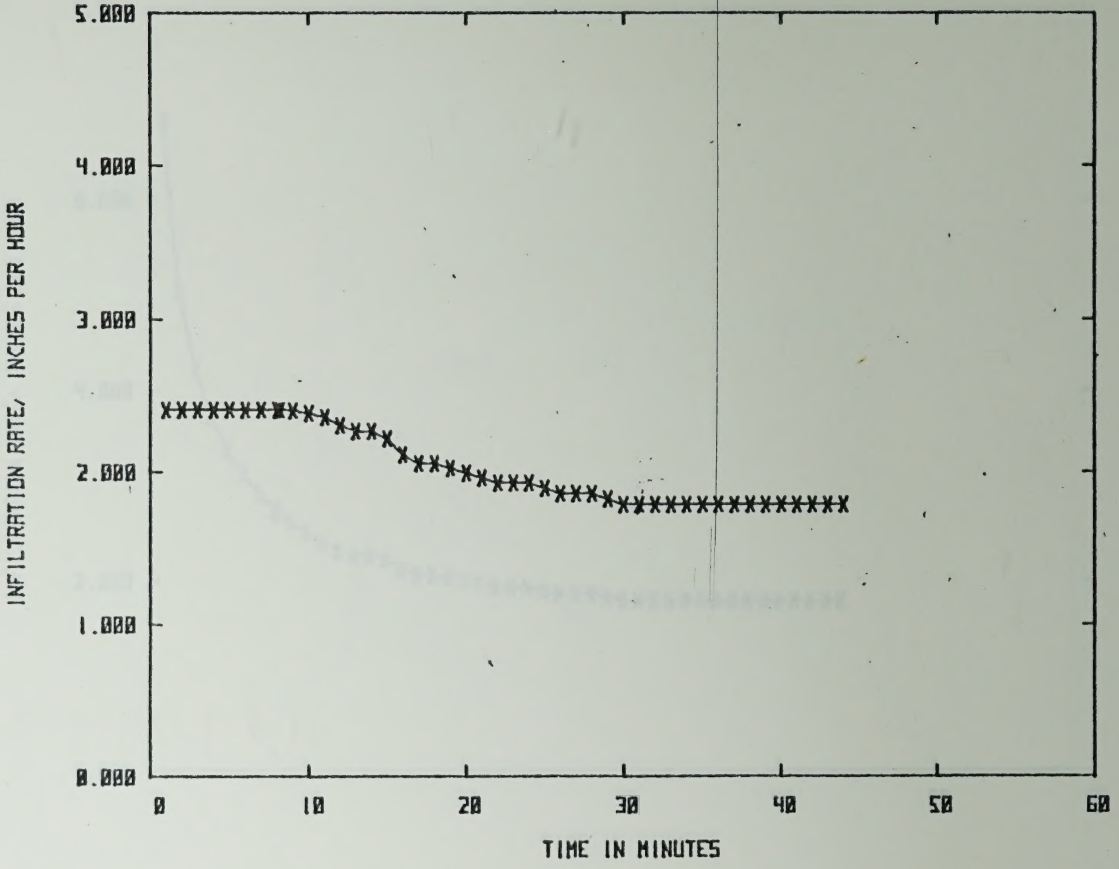
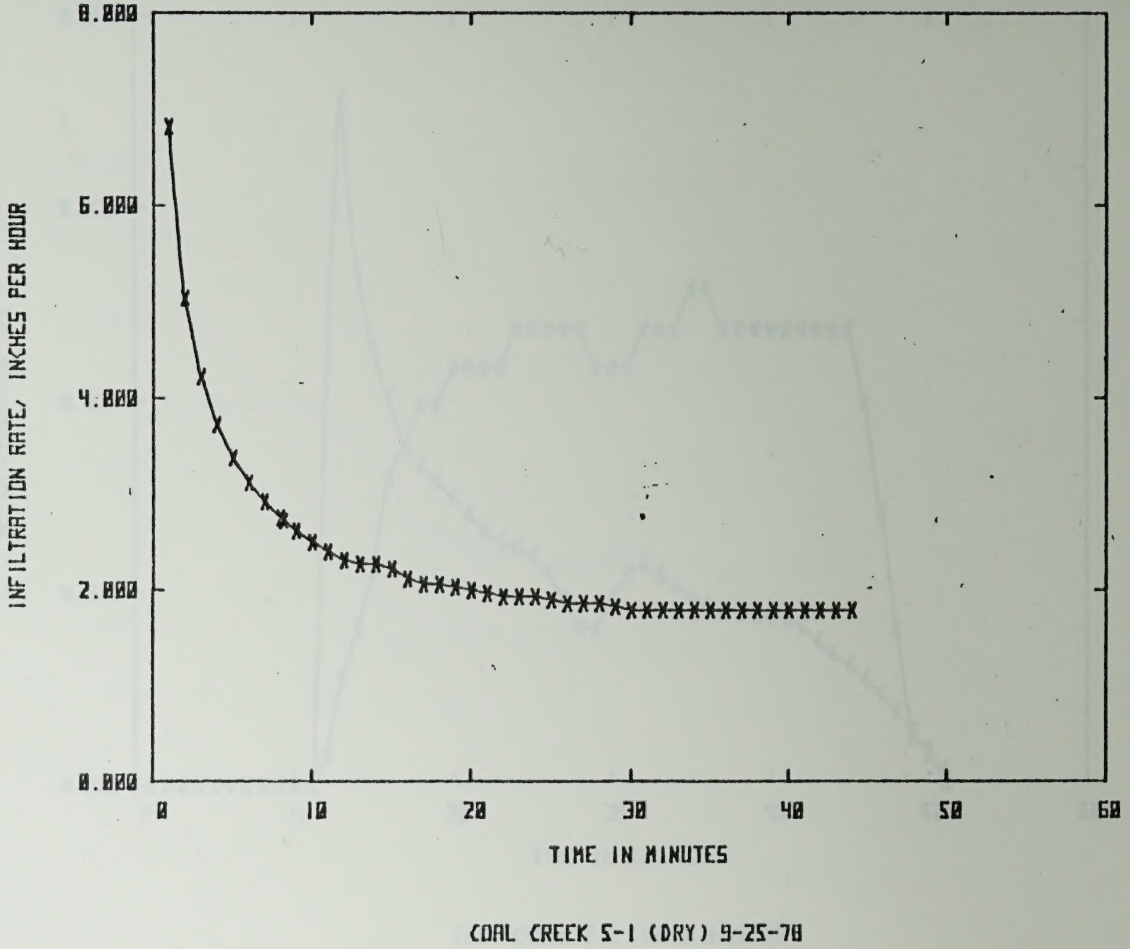
TIME IN MINUTES
COAL CREEK S-1 (DRY) 9-25-78



COAL CREEK S-1 (DRY) 9-25-78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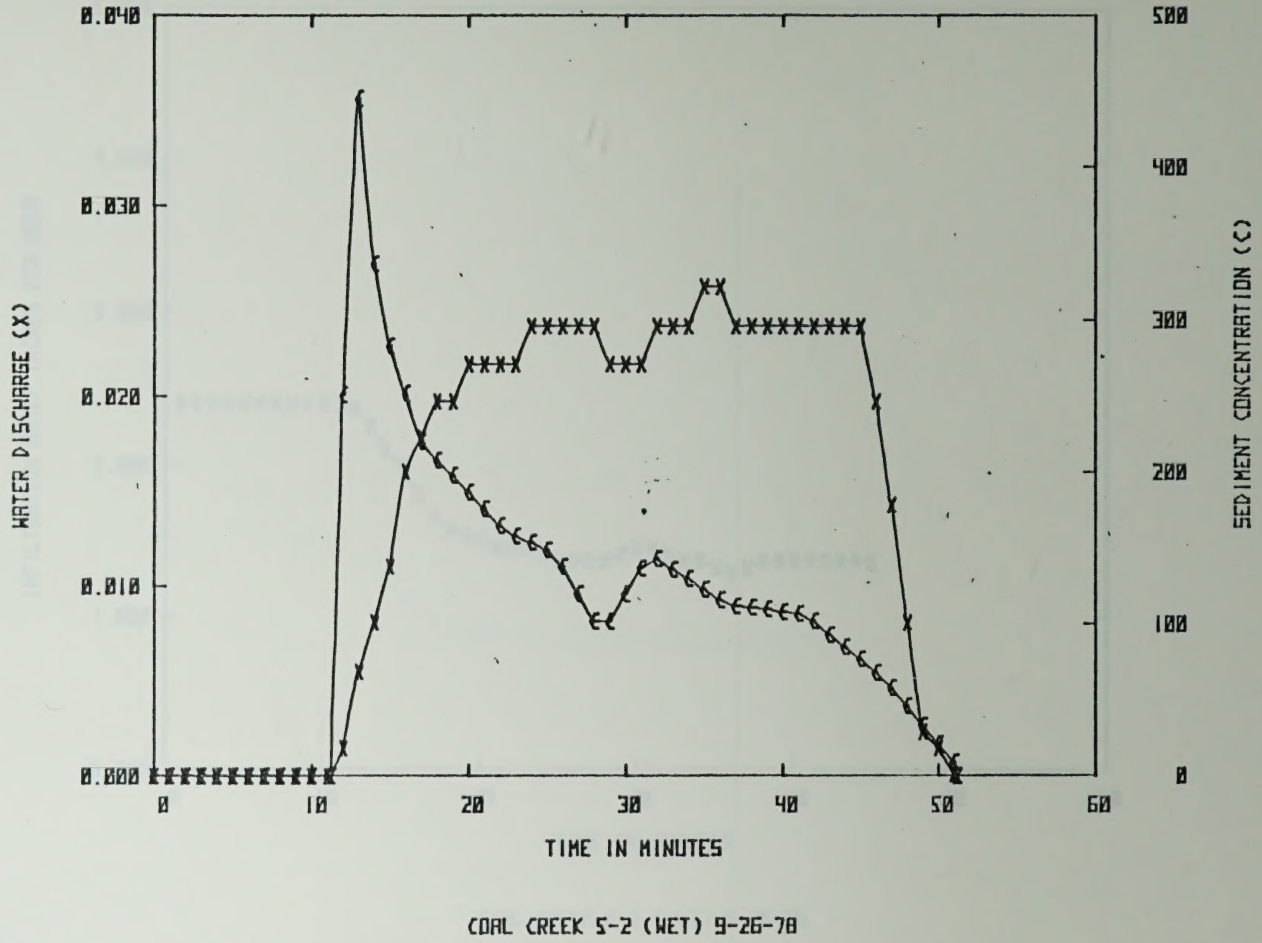
TIME IN MINUTES
COAL CREEK S-1 (DRY) 9-25-78



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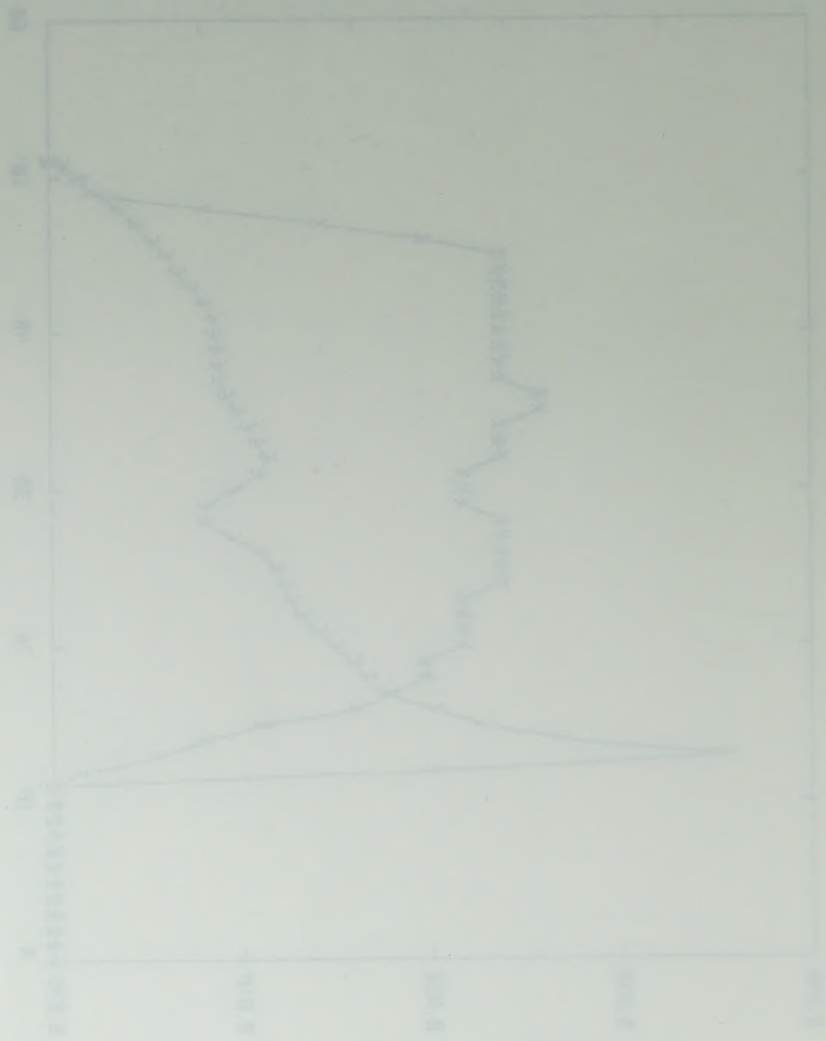

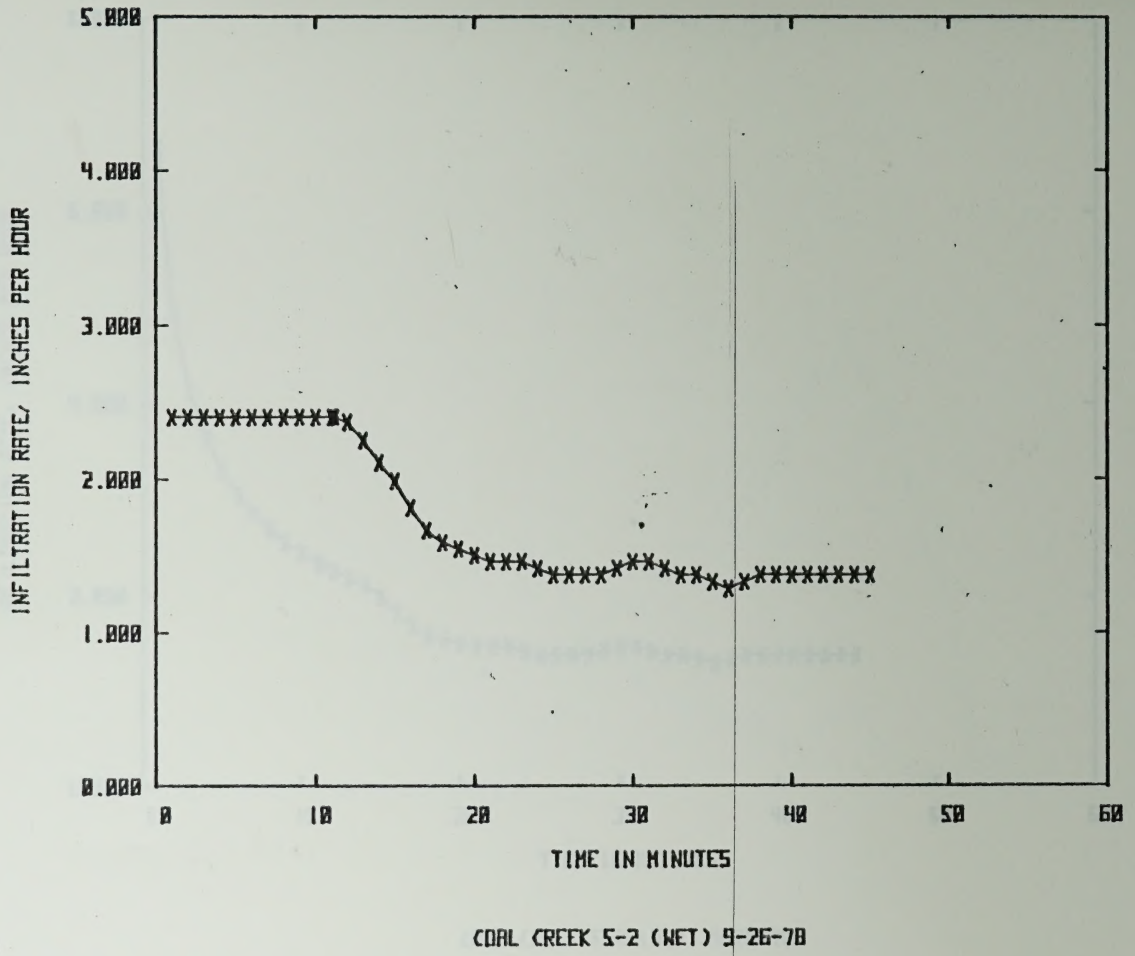
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INFILTRATION RATE, INCHES PER HOUR
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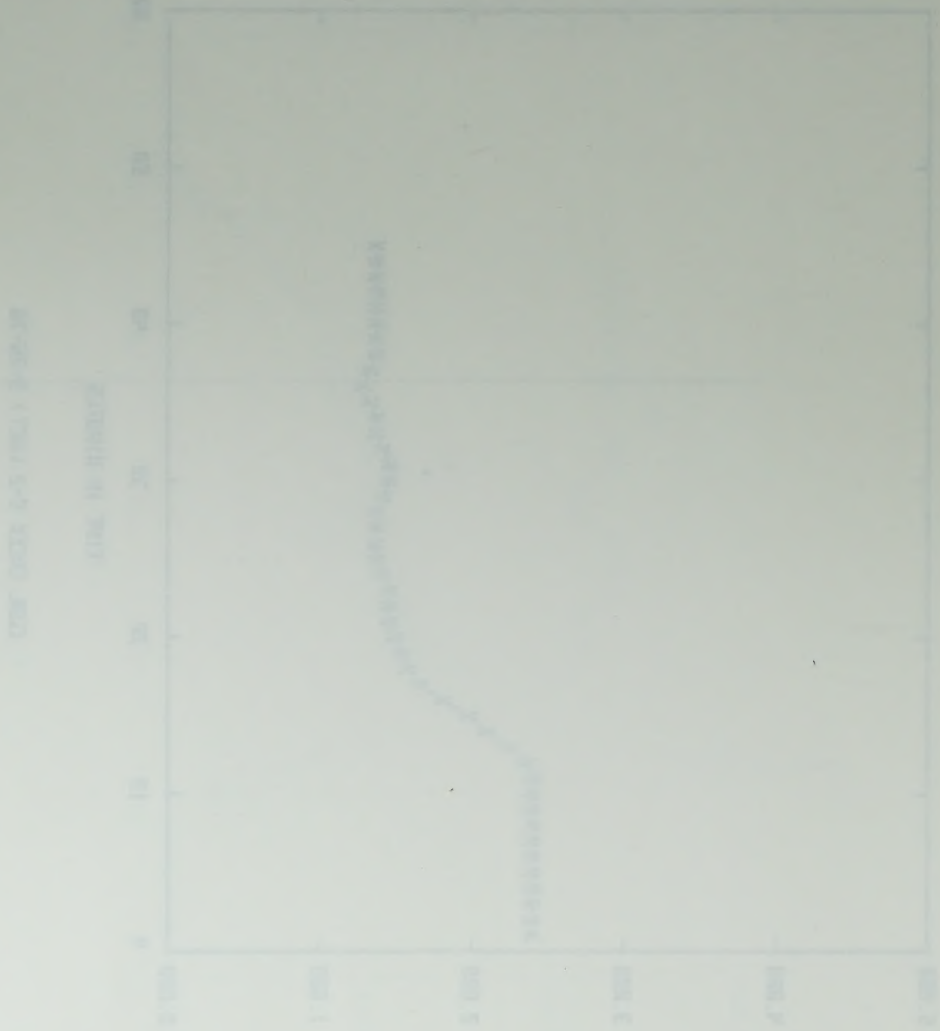
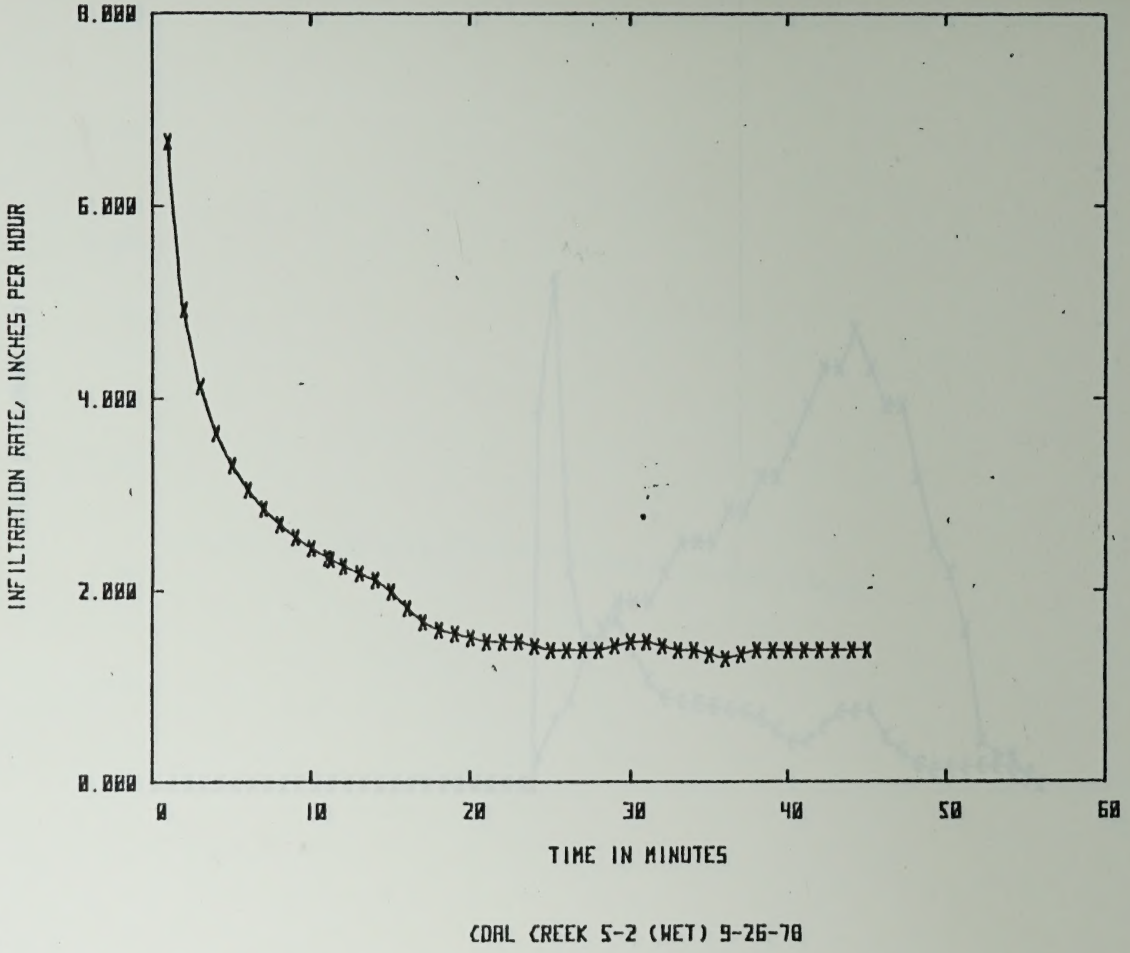
TIME IN MINUTES
COAL CREEK S-2 (WET) 9-26-78





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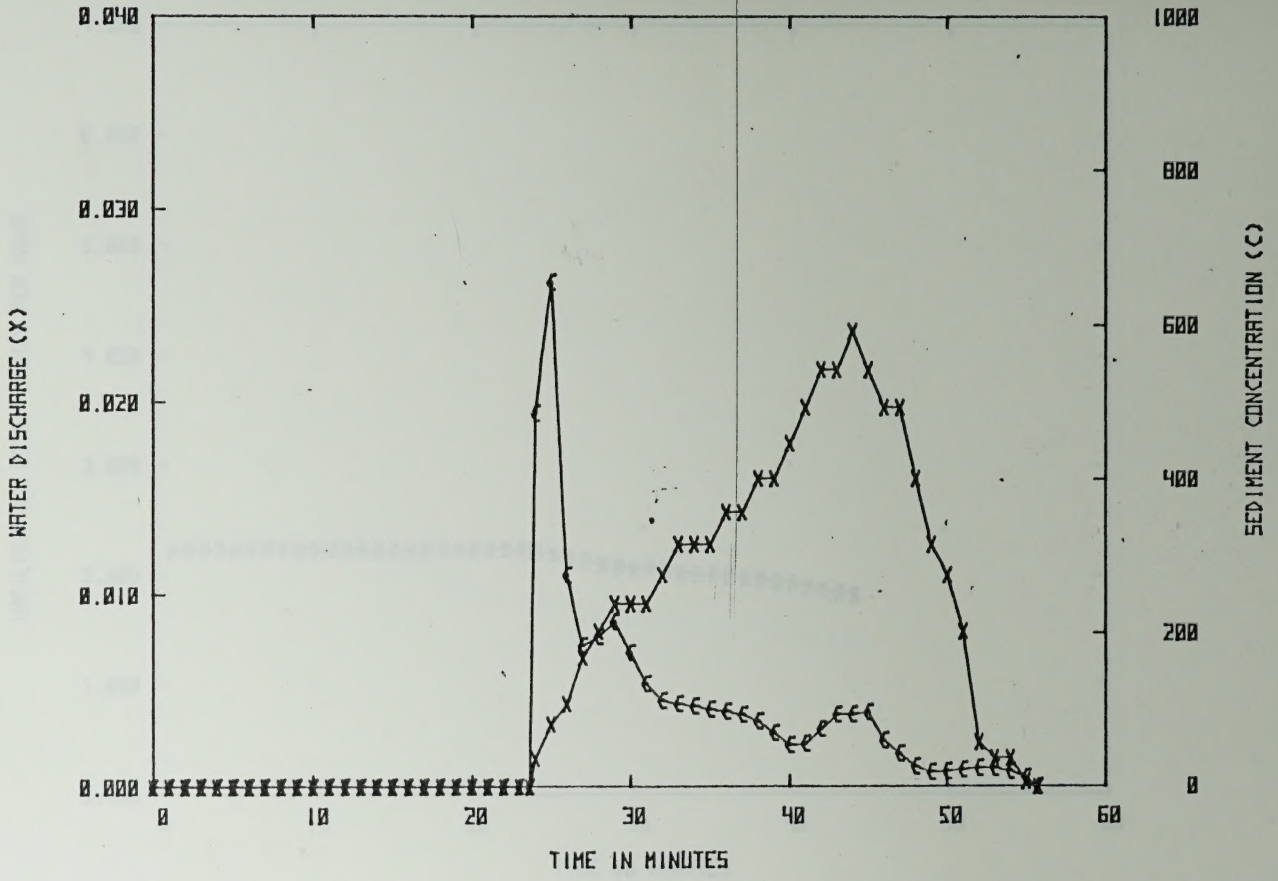
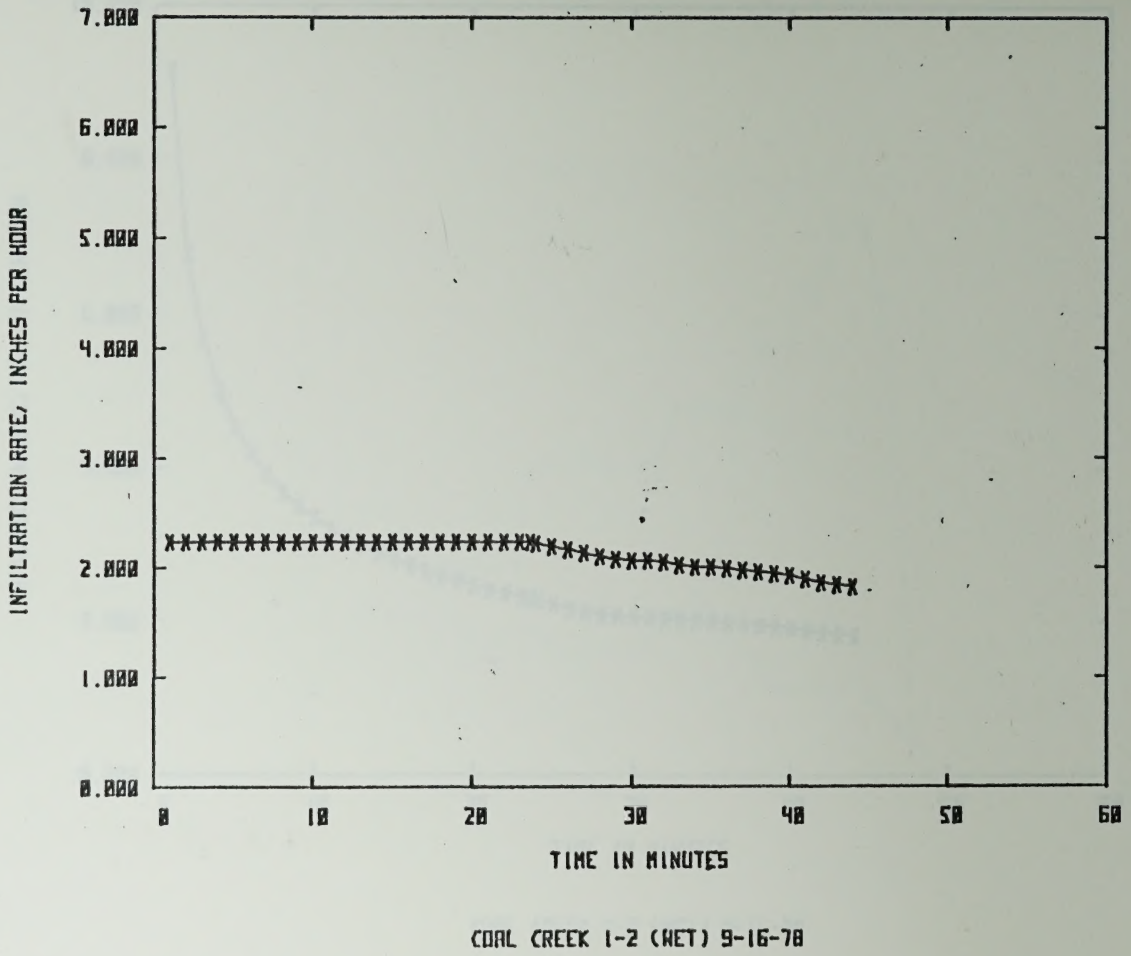


COAL CREEK 1-2 (WET) 9-16-78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INFILTRATION RATE, INCHES PER HOUR
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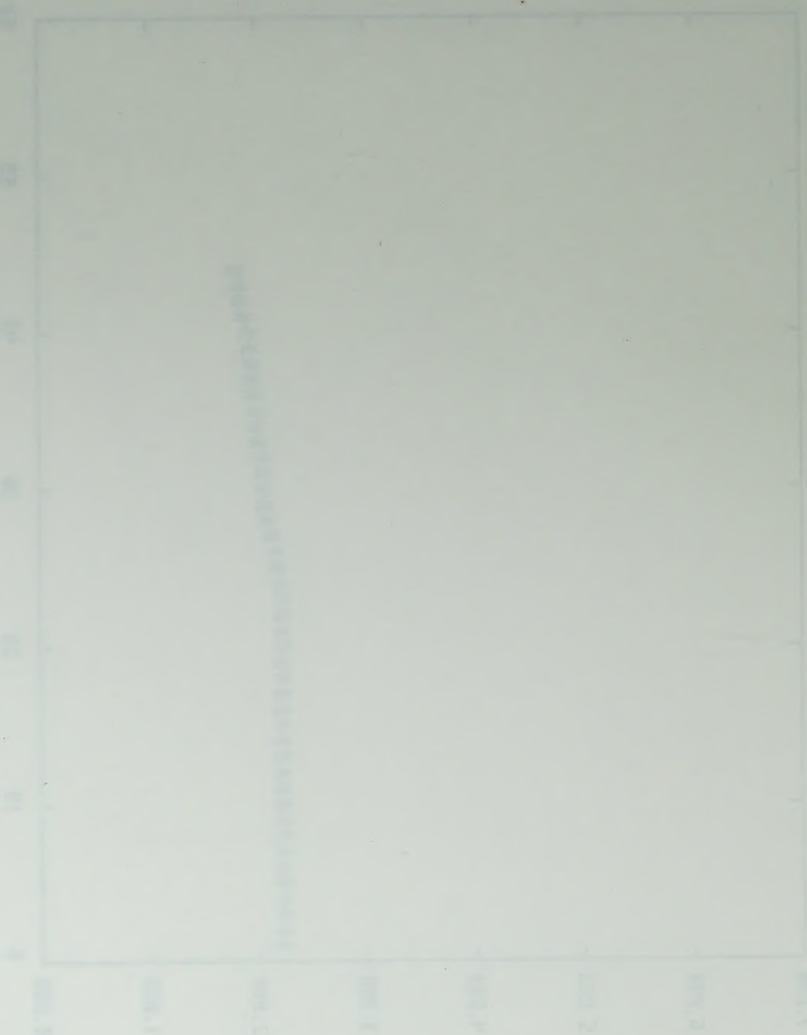
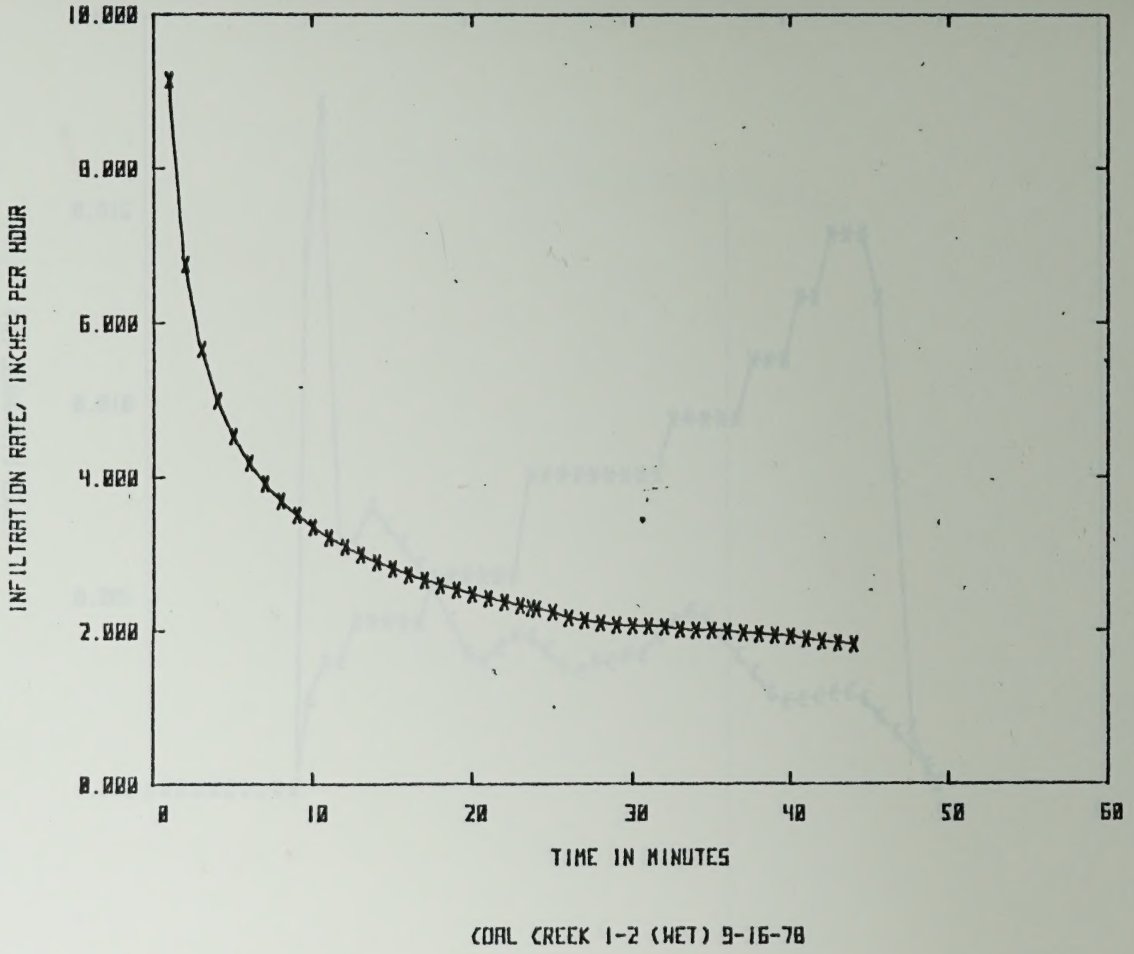
TIME IN MINUTES
COAL CREEK 1-2 (WET) 9-16-78

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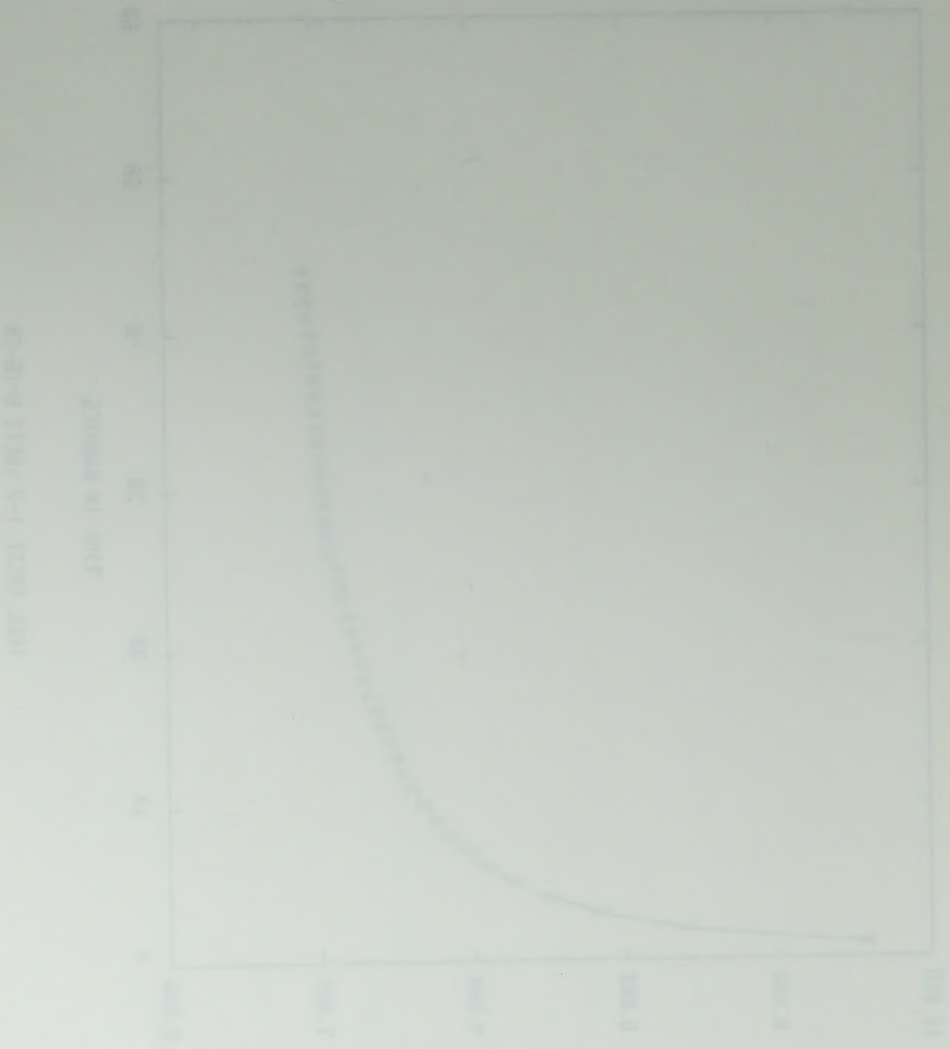
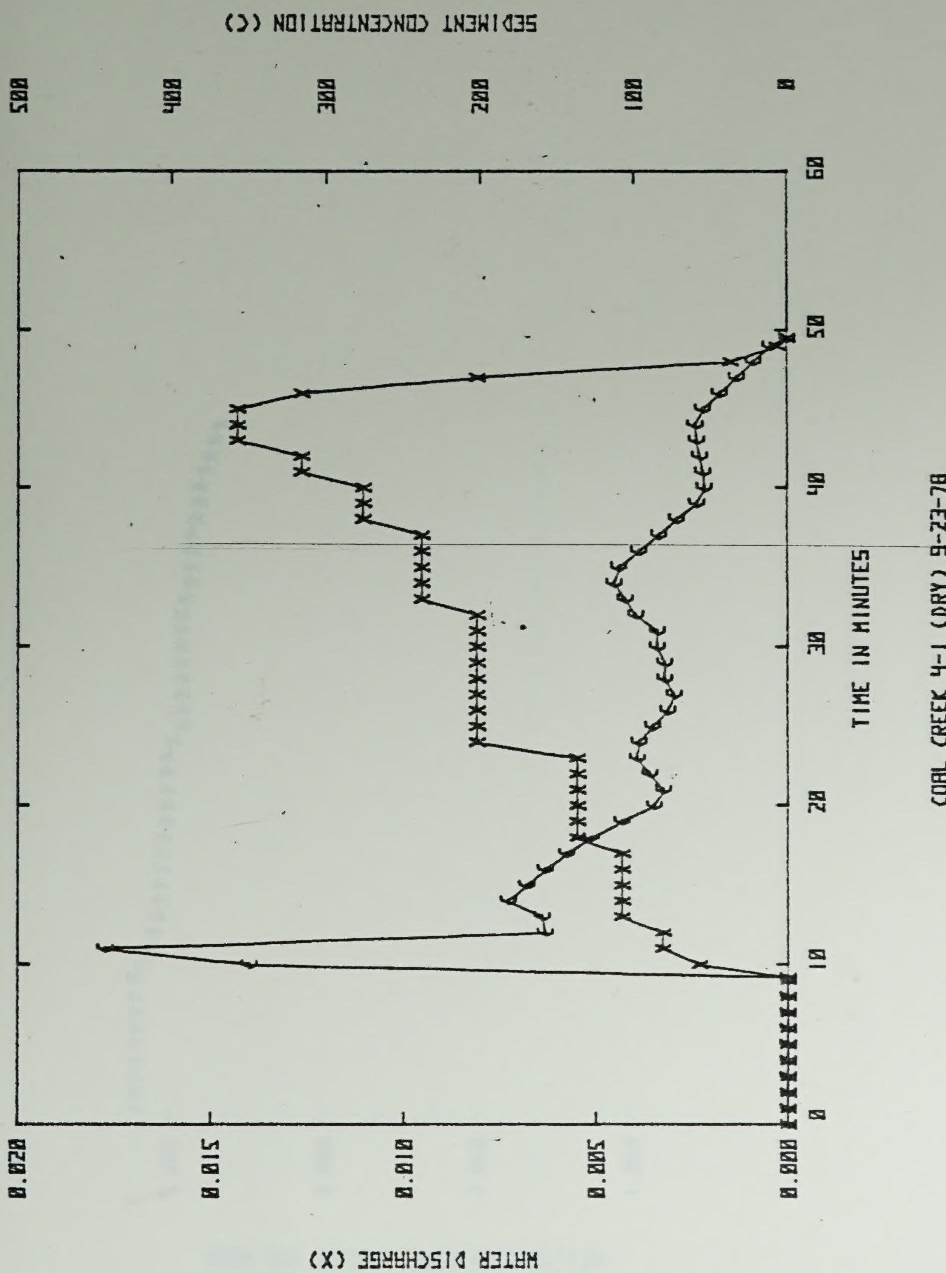
COAL CREEK 1-2 (WET) 9-16-78

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400
300
200
100
0
WATER DISCHARGE (X)
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0.015
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0.005
0.000
TIME IN MINUTES
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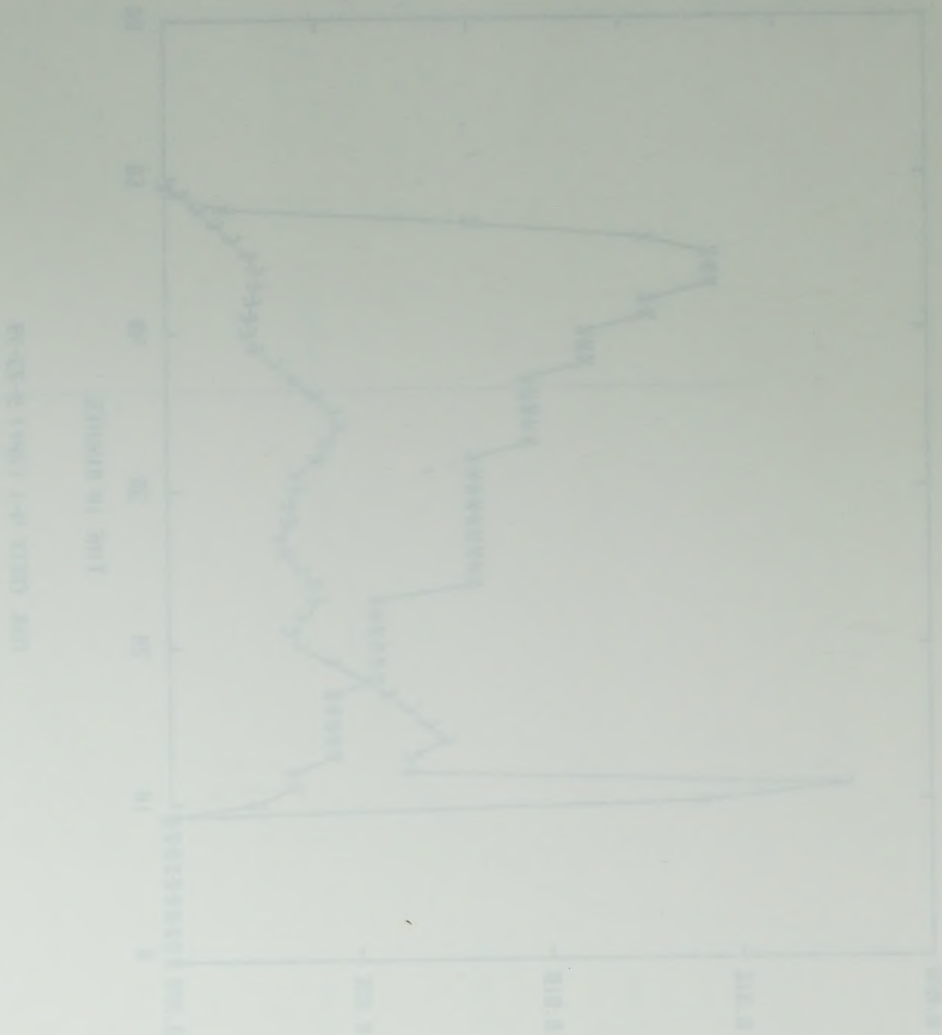
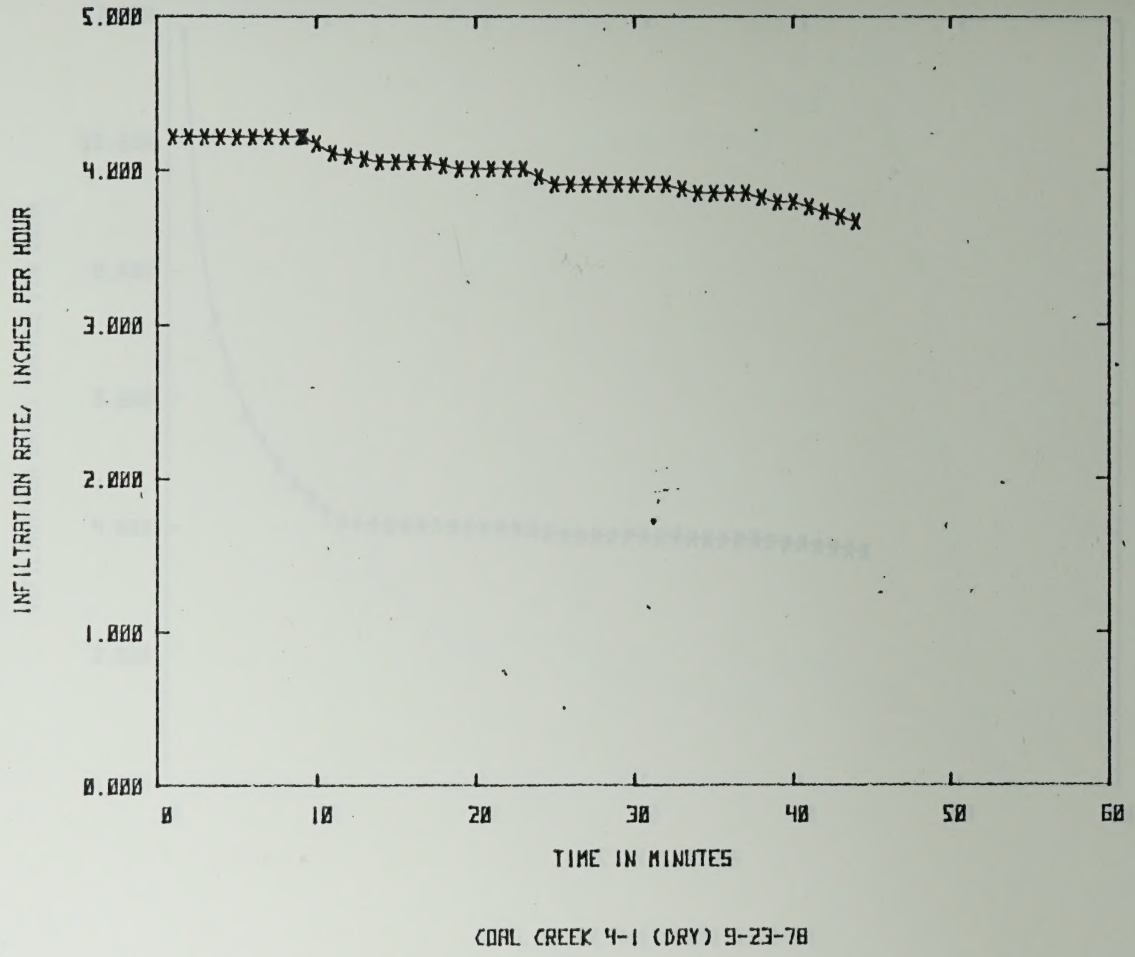
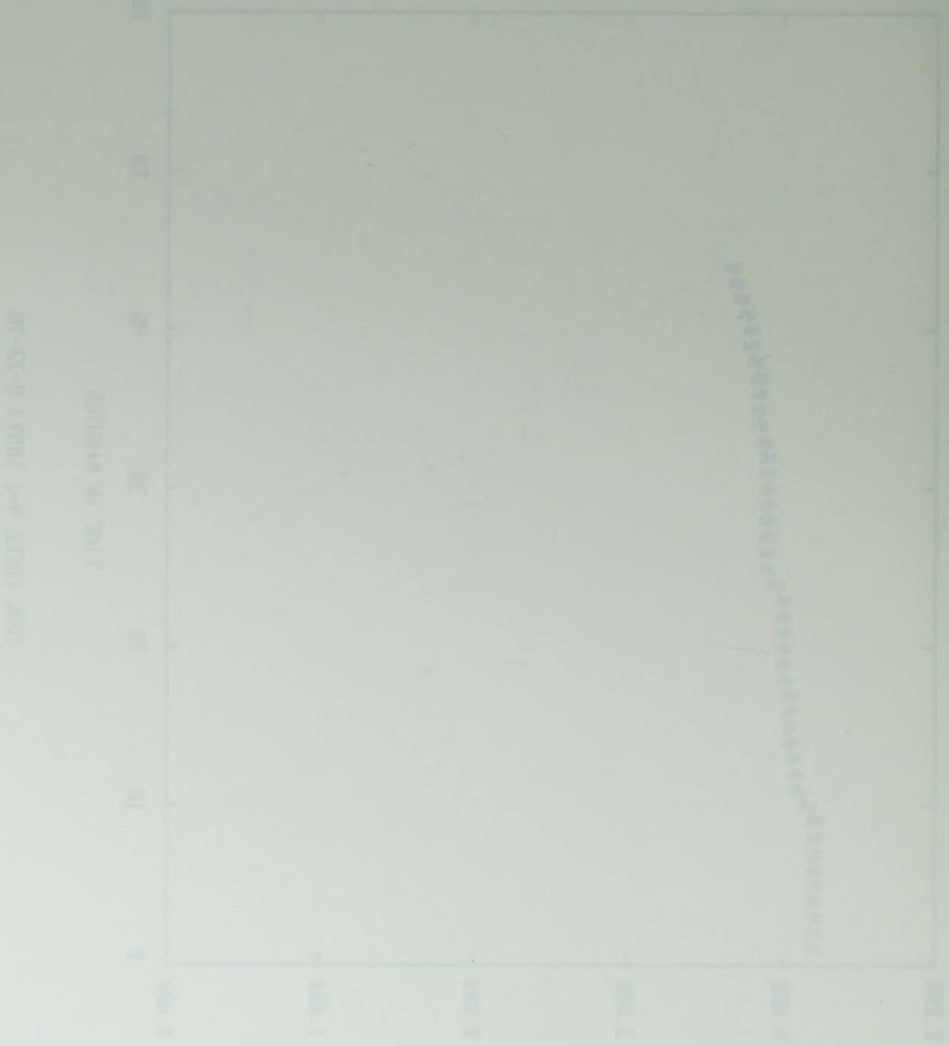
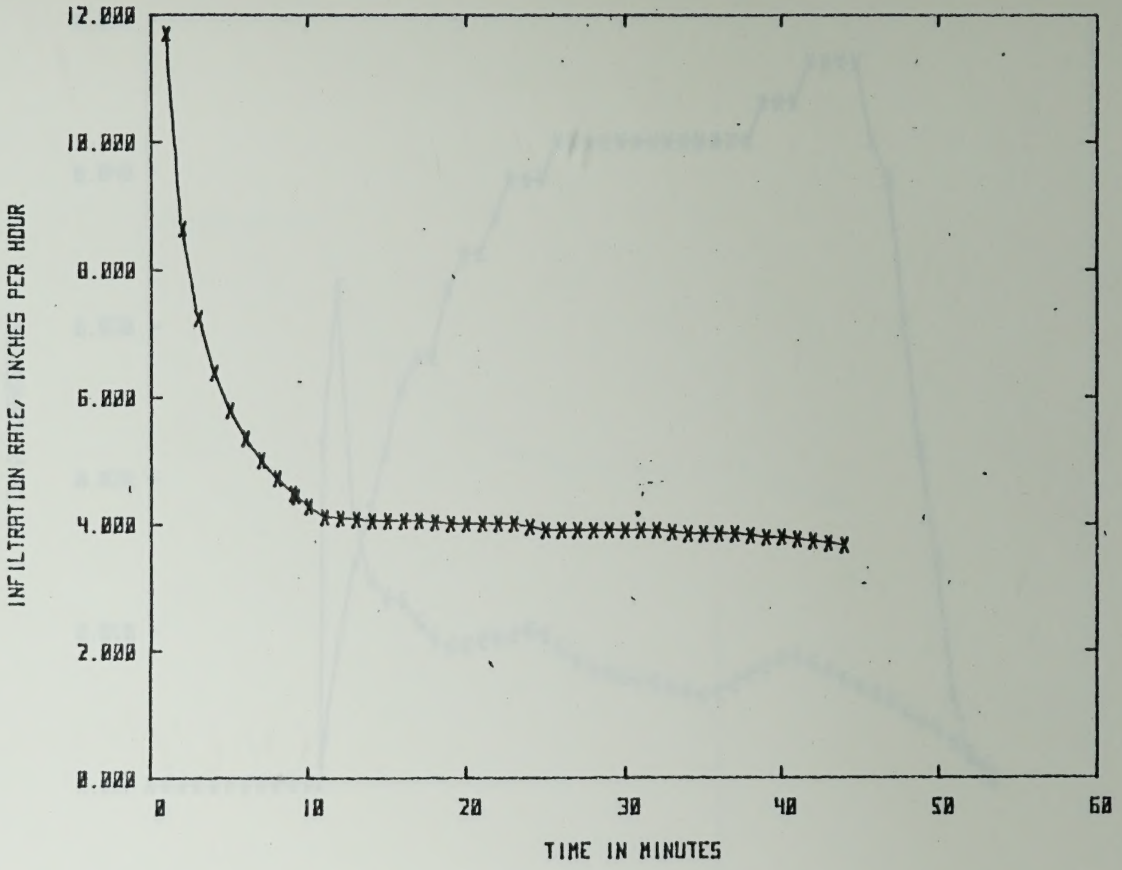
COAL CREEK 4-1 (DRY) 9-23-78

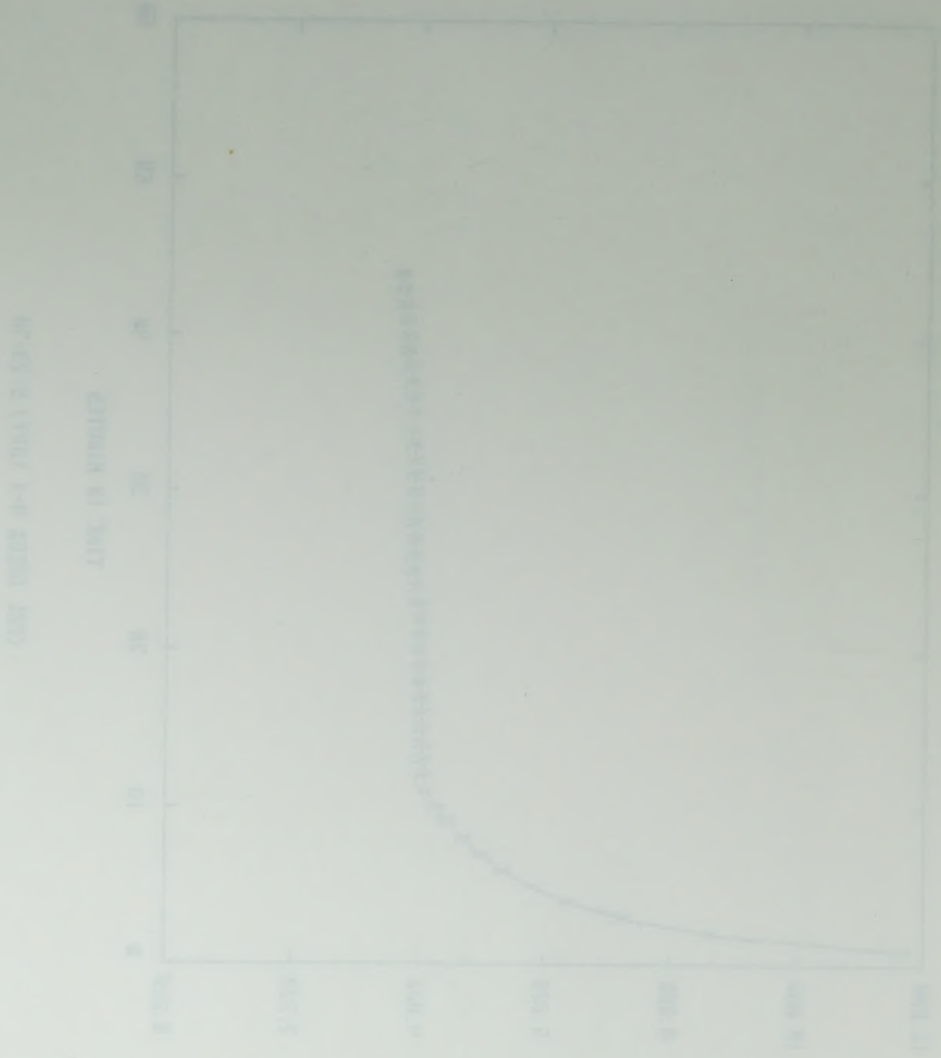


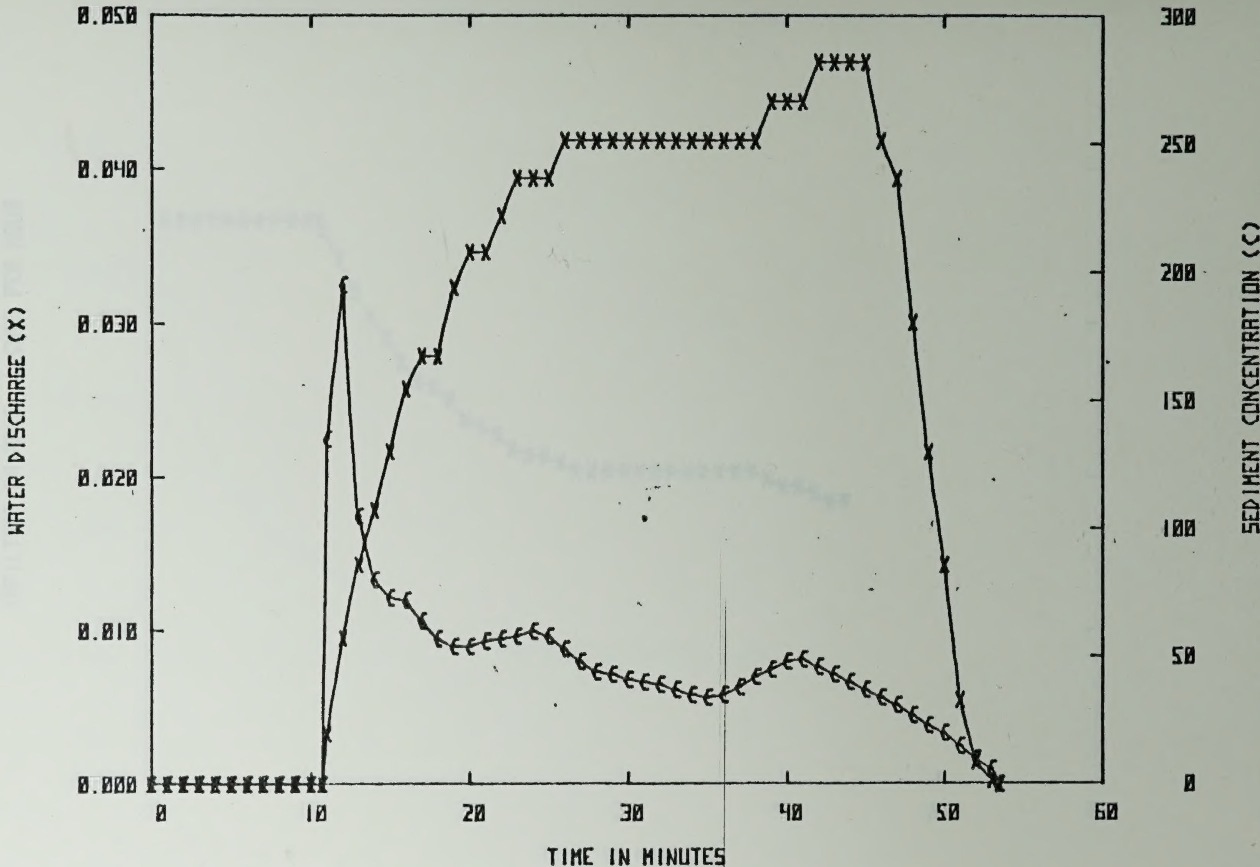

5.000
4.000
3.000
2.000
1.000
0.000
INFILTRATION RATE, INCHES PER HOUR
0
10
20
30
40
50
60
TIME IN MINUTES
COAL CREEK 4-1 (DRY) 9-23-78



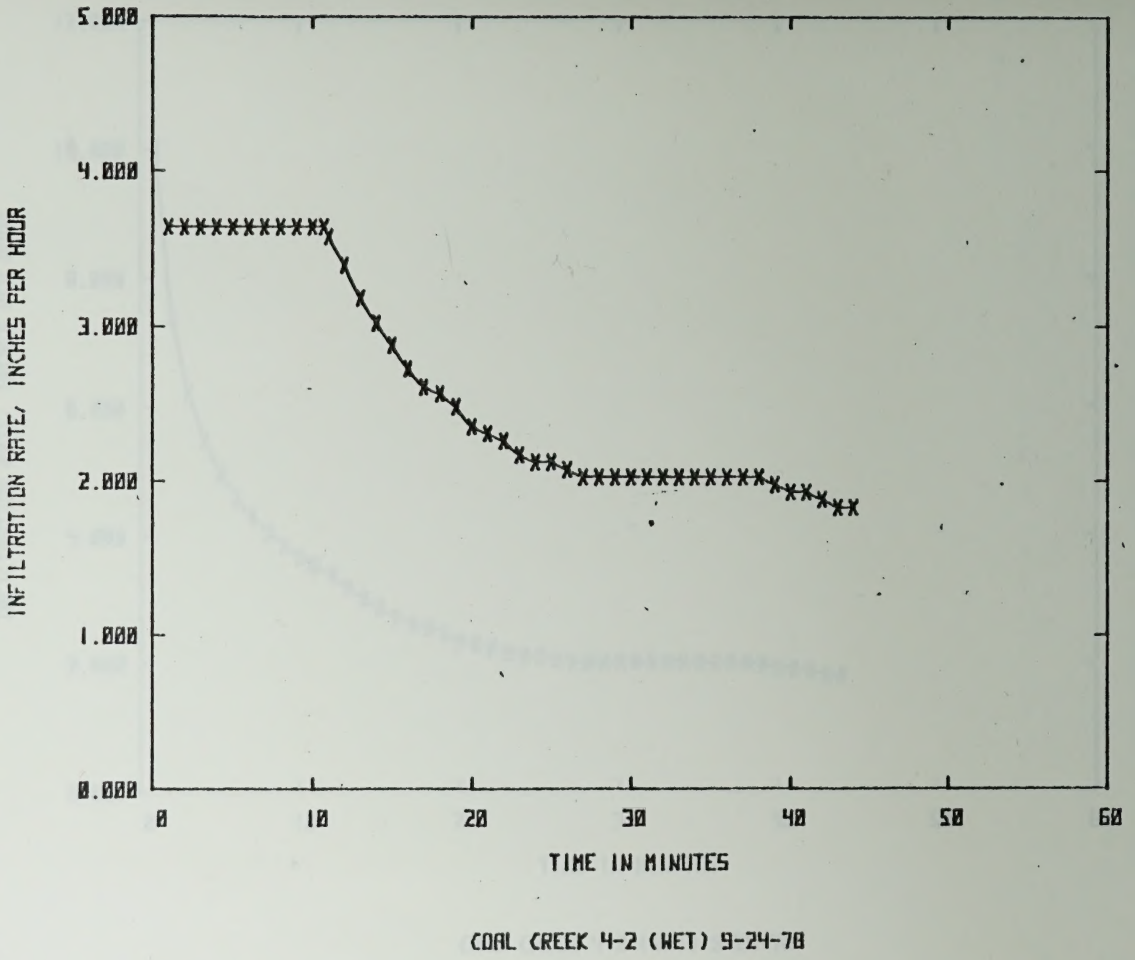


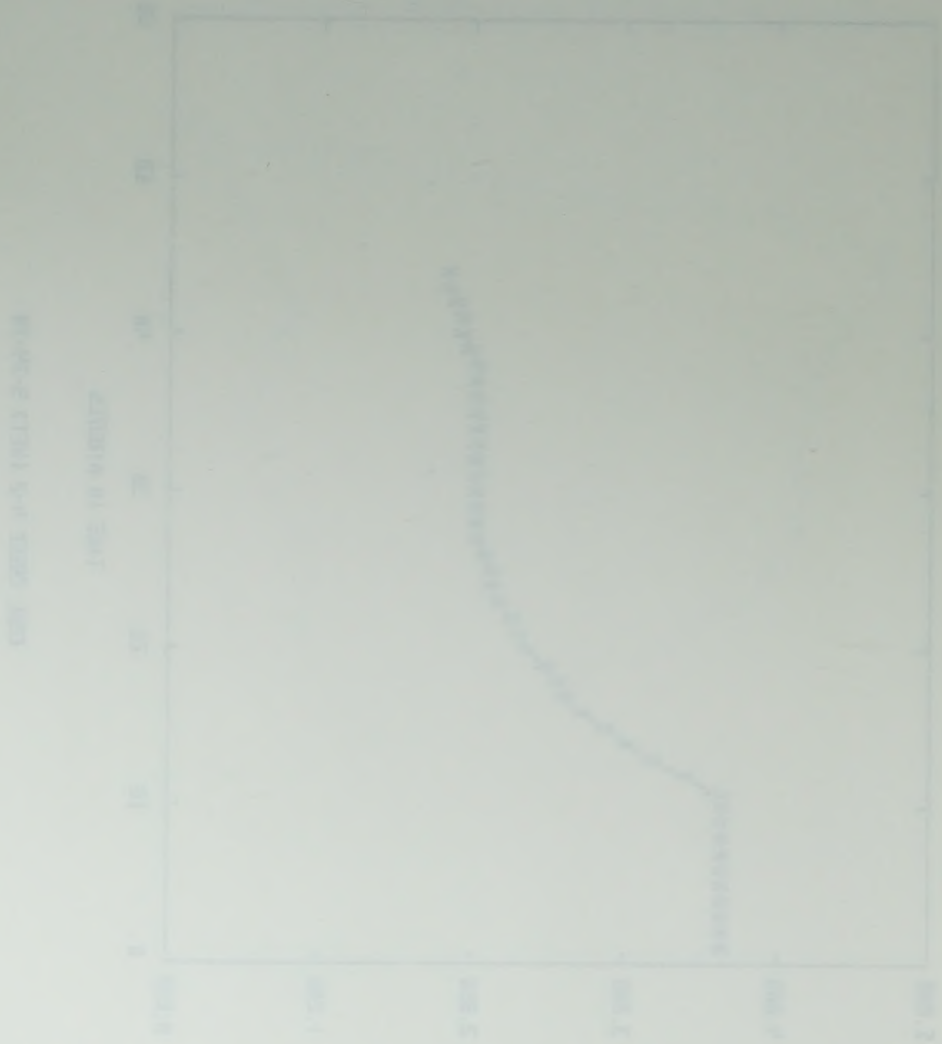
COAL CREEK 4-1 (DRY) 9-23-78

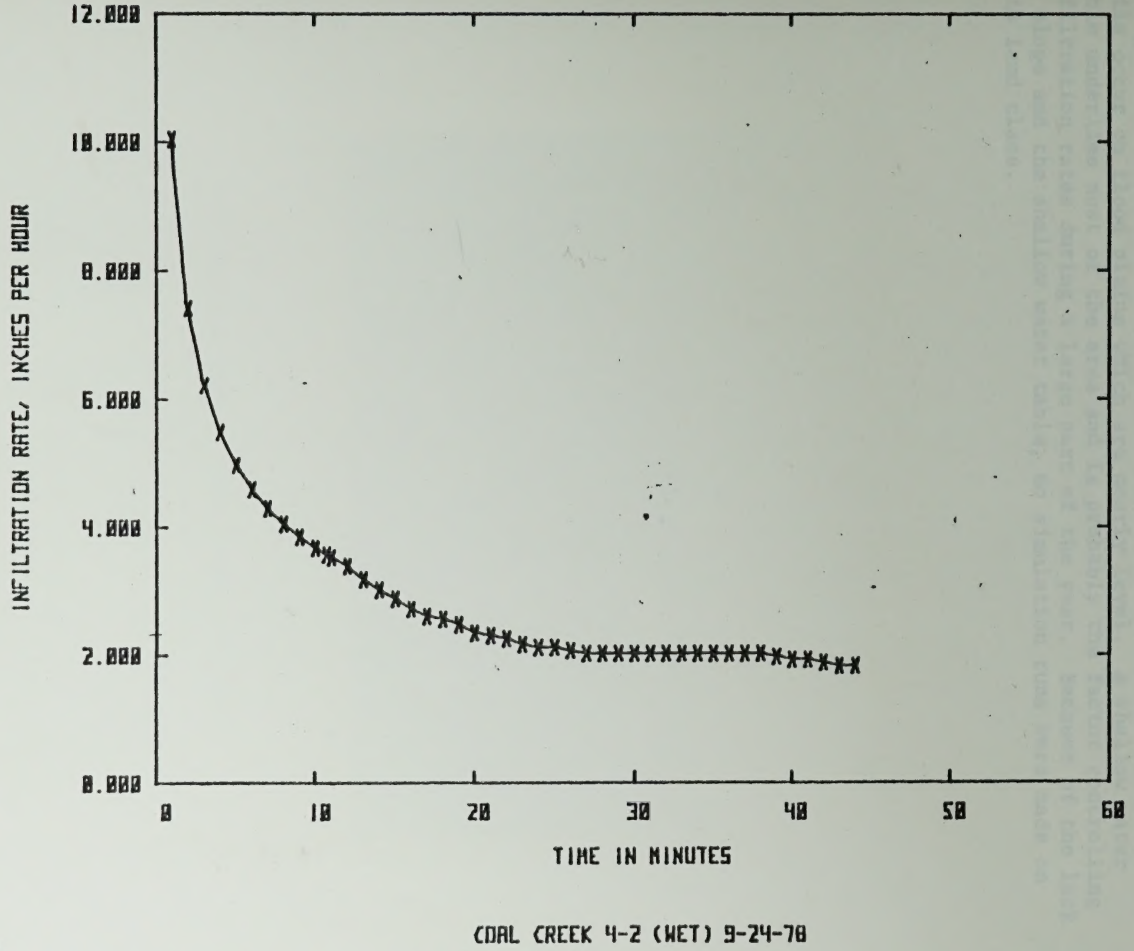




COAL CREEK 4-2 (WET) 9-24-78


5.000
4.000
3.000
2.000
1.000
0.000
INFILTRATION RATE, INCHES PER HOUR
0
10
20
30
40
50
60
TIME IN MINUTES
COAL CREEK 4-2 (WET) 9-24-78




12.000
10.000
8.000
6.000
4.000
2.000
0.000
INFILTRATION RATE, INCHES PER HOUR
0
10
20
30
40
50
60
TIME IN MINUTES
COAL CREEK 4-2 (WET) 9-24-78

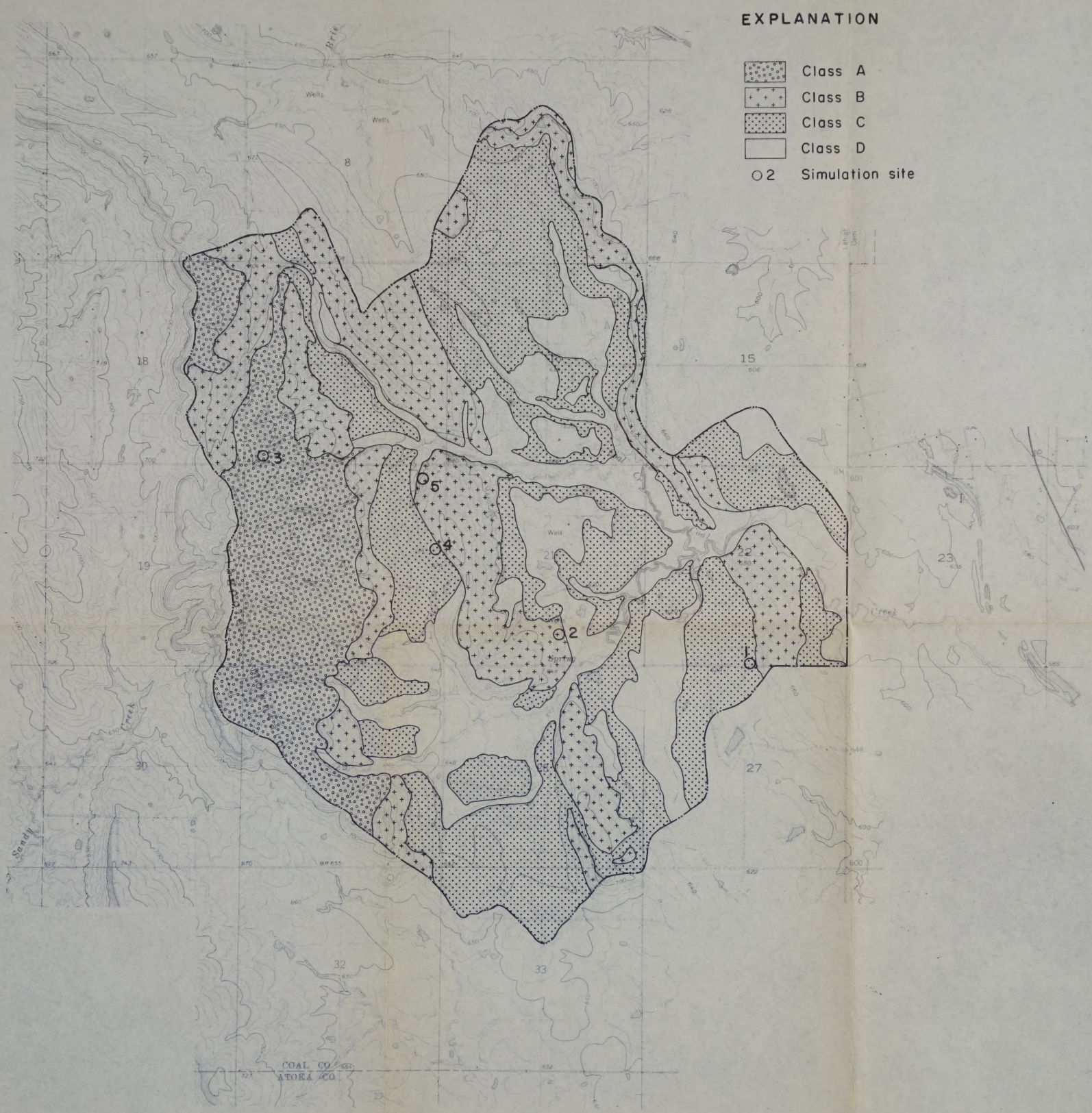
Class D

Class D consists of a mixture of Lanton, Carytown, and Ennis soils. About 27 percent of the drainage area is made up of this class. Both Lanton and Carytown soils were derived from shale and clay material and are classified as having slow or very slow permeability. Ennis soils were derived from limestone or shale material and are classified as having moderate permeability. In the upper Coak Creek basin, these soils occur on flood plains which are nearly level. A shallow water table underlies most of the area and is probably the factor controlling infiltration rates during a large part of the year. Because of the lack of slope and the shallow water table, no simulation runs were made on this land class.

Simulation site 1, Coal Creek, Oklahoma

Simulation site 2, Coal Creek, Oklahoma

Simulation site 5, Coal Creek, Oklahoma



Map of Coal Creek EMRIA study basin showing land class boundaries and simulation sites.